PHILOSOPHICAL

TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

LONDON.

FOR THE YEAR MDCCCLXXXII.

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ROYAL SOCIETY

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PART II.

LONDON:

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MDCCXXXIII.

Adjudication of the Medals of the Royal Society for the year 1882, by the President and Council.

The Copley Medal to Professor Arthur Cayley, F.R.S., for his numerous profound and comprehensive researches in Pure Mathematics.

A Royal Medal to Professor William Henry Flower, F.R.S., for his valuable contributions to the morphology and classification of the Mammalia, and to Anthropology.

A Royal Medal to Lord Rayleigh, F.R.S., for his various Papers in Mathematical and Experimental Physics.

The Rumford Medal to Captain William de Wiveleslie Abney, F.R.S., for his Photographic Researches and his discovery of the method of photographing the less refrangible part of the spectrum, especially the infra-red region, also for his Researches on the absorption of various compound bodies in this part of the spectrum.

The Davy Medal to D. Mendelejeff and Lothar Meyer, for their discovery of the periodic relations of the atomic weights.

The Bakerian Lecture "On the Chemical Theory of Gunpowder," was delivered by Dr. Debus, F.R.S.

The Paper "On the Rhythm of the Heart of the Frog, and on the nature of the Action of the Vagus Nerve," by Mr. W. H. Gaskell, was appointed as the Croonian Lecture.

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J. H. Gilbert, *Ph.D., F.R.S., F.C.S., F.L.S.,*
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PART II.—THE BOTANICAL RESULTS.

Introduction; Scope of the Experiments, and Mode of Experimenting.

IN Part I. (Phil. Trans., Part I., 1880), under the title of "*The Agricultural Results*," a general description of the experiments, with full particulars of the conditions of manuring of each of the more than 20 plots, was given. The effects of each condition of manuring on the character of growth of the herbage, as illustrated in the quantities of produce yielded, and in the amounts of nitrogen and of mineral matter taken up, on each plot, were also fully considered. But, so varied were the components of the mixed herbage, both as to the species grown, and as to the character of develop-

ment of the plants, that, to render the "*Agricultural Results*" sufficiently intelligible, and to prevent misconception, if the element of quantity only were taken into account, it was found necessary to describe, in general terms, the differences—in the botanical composition, in the character of development, and in some points in the chemical composition of the produce also. The object of the present section is to describe and discuss, more in detail, what may be called the *botany* of the plots;—that is, to show both the normal botanical composition of the herbage, and the changes induced by the application of the different manuring agents, and by variation in the climatal conditions of the different seasons; and, as far as may be, to ascertain what are the special characters of growth, above-ground or under-ground, normal or induced, by virtue of which the various species have dominated, or have been dominated over, in the struggle which has ensued.

The first season of the experiments was 1856. In that year 13 plots, in 1858 four others, in 1865 one, and in 1872 two more, were brought under experiment; thus making 20 in all. But, of these, two have been subdivided, so that the number may now be reckoned as 22.

As already stated, even in the first years of the experiments it was observed that those manures which are the most effective with wheat, barley, or oats grown on arable land—that is with gramineous species grown separately—were also the most effective in bringing forward the grasses proper, in the mixed herbage. Again, those manures which were the most beneficial to beans or clover the most developed the leguminous species of the mixed herbage, and *vice versâ*. It was further observed that there was great variation in the predominance of individual species among the grasses, and also among the representatives of other orders.

Indeed, in the second year, 1857, the differences in the floras were so marked that a first attempt was then made to separate and determine the proportion of each separate species, in carefully averaged and weighed samples taken from several of the plots at the time the crops were cut; and, taking advantage of the experience thus gained, more careful separations were undertaken in the case of samples of the produce of seven of the most characteristically different plots in the third season, 1858. The results relating to the produce of 1858 were published in Vol. xx. of the Journal of the Royal Agricultural Society of England, in 1859. In these early trials, for the superintendence of which we were indebted to the late Dr. Evan Pugh of Pennsylvania, the samples were separated into:—

1. Gramineous herbage; stems bearing flower or seed.
2. Gramineous herbage; detached leaves and indeterminate stems.
3. Leguminous herbage.
4. Miscellaneous herbage.

In all, only 11 grasses, three leguminous plants, and nine plants of other orders, were then identified in the samples, though undoubtedly many more were present;

and, under the head of "Gramineous herbage, detached leaves, and indeterminate stems," in one case as little as 15 per cent., and in another more than 53 per cent. of the total was recorded. This result at once illustrates both the difficulty of the work, and the great difference in the character of growth on the different plots.

From year to year the plots became more and more characteristic; and in the seventh season, 1862, it was decided to undertake much more complete botanical separations. To this end it was necessary, not only to expend much more time and labour in the work, but to obtain the services of a competent assistant to devote attention exclusively to it. Accordingly, we applied to Dr. (now Sir Joseph) Hooker, who kindly recommended to us such an assistant; as he has also done on three subsequent occasions, at intervals of five years—namely, in 1867, 1872, and 1877. Thus, the botanical work was superintended in 1862 by Mr. W. Sutherland, in 1867 by Mr. Richard L. Keenan, in 1872 by Mr. W. B. Hemsley, and in 1877 by Mr. Walter Davis. In each of these four seasons of more complete separations, Mr. J. J. Willis, of the Rothamsted Laboratory, assisted whenever able to do so, and from the experience thus gained was on each subsequent occasion enabled to afford substantial aid to the new comer. Mr. Willis has also, especially in recent years, annually made notes, at intervals, on the herbage of the growing crops, and he has conducted partial separations on several occasions. On each occasion, whether of more complete or of only partial separation, from three to six boys have also been occupied in the work.

The Samples: their botanical analysis.—The mode of taking and treating the samples may be briefly described as follows: Eight or ten mowers being put upon the experimental plot, the botanical assistant followed, taking small quantities of grass immediately after the scythe from each swath, until nearly the whole of the plot was down; boys also followed, with hampers or sacks, for the collection of the samples so taken. The quantities thus collected amounted to very many times more than was required for botanical analysis. They were at once carefully mixed on a cloth, so as to shake out seed, or otherwise damage the herbage, as little as possible; and from the bulk a sample of 10, 12½, 15, or even 20 lbs., according to circumstances, was then immediately weighed. The weighed samples were spread out on cloths, at the ordinary temperature, to dry, and were then carefully preserved for future examination.

In the conduct of the separations each worker had a small handful of the mixed herbage placed before him, which he separated into its various component species as far as he was able. From time to time the superintendent revised each of the so separated portions. But there always remained an undetermined residue, which varied in amount exceedingly, according as the herbage was simple or complex, stemmy or leafy, mature or immature, and so on. These at first undetermined residues, after some reduction in the hands of the superintendent, were next separated into portions of different character by means of sieves of various gauges, by which the examination and the identification of the various components were much facilitated.

Still, these further separations were always very tedious and laborious; and, as will be seen hereafter, the amount of finally undetermined residue varied very considerably according to the description, and the character of development, of the herbage. It will be readily understood that a very luxuriant and stemmy gramineous produce would be much more easily separated into its components than a mass consisting chiefly of fine leafy matter. To quote an extreme case in illustration of the difference in the character of the herbage, and of the difference in the degree of difficulty of separation accordingly, it may be mentioned that whilst a sample of 20 lbs. from one plot in 1872 only occupied from four to five days in botanical analysis, a sample of equal weight from another plot in the same year occupied 30 days.

In further explanation of the mode of procedure it may be stated that, in addition to the examination of the growing plants at intervals during the season, prior to the cutting of the crops the botanical assistant, after spending some days on the ground to become acquainted with the character of the plots, made systematic notes upon them. The instructions given to him were—to enumerate, in the order of their apparent predominance on each plot, 1, the Gramineous species; 2, the Leguminous species 3, the species of other Orders—classed together for convenience as "Miscellaneous" species; to estimate, as far as practicable, the probable proportion in which the most prominent species occurred, stating, at the same time, on what basis the estimate of relative predominance was formed—whether merely on the quantity of flower stems or of probable total plant, &c., noting the circumstances probably affecting the degree of accuracy of the estimate; also to state the general characteristics of the distribution, and of the growth, on each plot—what plants were flowering or showing greater or less flowering and seeding tendency, the order of forwardness, &c., and also any special point observable.

After thus describing the herbage on each plot, the next point was to consider the normal characteristics of growth of each important species, and to compare its predominance, and its distinctive characters of development, if any, on the different plots; especially noting differences in tendency to form more leaf, more stem, &c.; also differences in colour, degree of forwardness, fertility, barrenness, and the like. Careful observations were also to be made as to what particular "Natural Orders," if any, seemed to be characteristic of the herbage of the different plots.

Then, within a few days of the time of cutting, the general order of ripeness of the components of each plot was noted, stating particularly what plants—gramineous, leguminous, or miscellaneous—were flowering or seeding, and especially which would probably self-sow the ground.

Again, at the time of and after mowing, further observations were made with a view to the confirmation or correction of the notes previously recorded; and also to ascertain what plants, if any, occurred which had not been previously observed.

Lastly, after the removal of the first crops, and during the growth of the second crops, and especially just before these were cut or fed, as the case might be, notes were made on the progress and character of growth on the different plots; and sometimes,

when the crops were fed by sheep, observations were made as to what species were preferred and what were discarded by the animals.

Instructions were also given carefully to look for, and to note, throughout the whole enquiry, any characters of growth, normal or induced, above-ground or under-ground, by virtue of which it was probable that any one species dominated over others, or in consequence of which the plants dominated over had succumbed.

In 1862, 20 samples of the mixed herbage, of 10 lbs. each, were submitted to botanical separation; and the work occupied Mr. SUTHERLAND, several boys, and occasionally Mr. WILLIS, for about four months; and Mr. WILLIS and the boys for about two months more. The results so obtained were published in Vol. xxiv., Part I. of the Journal of the Royal Agricultural Society of England (1863). But, even in the case of these separations, which were so much more elaborate than the earlier ones, the quantity of undetermined stem, leaf, and shedded flowers and seeds varied from under 5 to nearly 28 per cent. of the total sample. These at first undetermined residues have, however, since been much farther worked down; and the results given in the present paper relating to the produce of 1862 are, accordingly, considerably amended as compared with those originally published as above referred to.

In 1867, 20 samples of 10 lbs. each and one of 20 lbs. were operated upon. The herbage was generally more stemmy and riper than that of 1862. The separations were, therefore, less difficult; but they were carried further, about five months being devoted to the work; and the proportions of undetermined residue were less than in even the revised separations of the produce of 1862.

In 1872 most of the herbage was finer than usual, larger samples were taken than previously, the amount of matter left undetermined was very small, and the time devoted to the separations was much longer than formerly. Thus, in all, 23 samples were operated upon: 14 of 15 lbs., and 9 of 20 lbs. each; and the period occupied in the analysis of the samples of that year was between 10 and 11 months. Nearly three months were afterwards expended in the revision of the results relating to the produce of 1862, as above referred to; when the previously undetermined residues were on the average reduced to about one-third of the original amounts, and in many cases much lower.

In 1877, 24 samples of 12½ lbs. each were taken. In the work of separation, besides some new hands, two, and sometimes three, who had taken part in the detailed separations of 1872, and in partial ones in 1874, 1875, and 1876, were engaged. The work was more completely done than on any previous occasion, no undetermined residue whatever being left; and the time occupied was not quite five months.

Besides the complete separations into individual species, in samples from every plot in the four seasons of 1862, 1867, 1872, and 1877, partial separations, as above referred to, that is into three main divisions of—

Gramineous herbage,
Leguminous herbage,
Miscellaneous herbage,

have been executed in the case of selected plots, first and second crops, as under :—

	First crops.	Second crops.	Total.
1871	5	—	5
1874	5	—	5
1875	9	9	18
1876	8	—	8
1877	(Complete)	11	11
1878	14	11	25
1879	12	8	20
1880	12	6	18

These partial separations have been superintended by Mr. WILLIS, excepting those of the second crop of 1877, which were conducted by Mr. WALTER DAVIS.

Finally in regard to the samples, although there can be no doubt that they do represent the actual vegetation of the plots at the time of cutting with close approximation to correctness, it is to be remembered that some plants may by that time have grown up and already to a great extent disappeared, whilst others may escape the scythe by reason of their dwarf and lowly habit. It is obvious, however, that any inaccuracies in the indications of the botanical separations arising from such causes must, from the very nature of the case, be but small, and that they will practically be confined to the results relating to plants of only scanty occurrence or meagre development. The notes taken on the ground do, indeed, show that the range of error due to the causes referred to is not material.

Characters of the Seasons in which Complete Botanical Separations were conducted.

In the section on the "Influence of Season on the Produce of Hay," Part I., pp. 390 to 405, it has been shown how very great was the difference in the amount of the mixed produce dependent on the climatal conditions, and also what widely different seasons might yield large, and again, what widely different seasons might yield small crops. In fact, a given quantity of the mixed produce grown under the same conditions as to manuring, might be composed very differently in two different seasons. This difference was stated, in general terms, to consist not only in the different proportions in which the various Orders, genera, or species were represented, but also in the character of development of the plants in regard to leafiness or stemminess, luxuriance and succulence, or maturation, &c. It is obvious that, if this be so, it is essential to consider the characters of the seasons themselves, in which the botanical separations were made; and to come to some conclusion as to their probable influence on the botanical composition, and the character of development, of the mixed herbage, apart from that of progressive exhaustion of the soil, or the continued application of different manuring substances; so as in some degree to discriminate between results due to the

Table XXXIII.

	Plot 3. Unmanured continuously.	Plot 7. Mixed mineral manure, alone.	Plot 9. Mixed mineral manure, and 400 lbs. ammonia-salts.	Plot 11. Mixed mineral manure, and 800 lbs. ammonia-salts.	Plot 14. Mixed mineral manure, and 550 lbs. nitrate soda.	Means.
Total Number of Species Found.						
1863	50	44	32	25	28	35
1867	43	42	29	19	30	33
1872	49	41	30	16	30	33
1877	52	44	27	16	27	33
Average of the 4 years	48	43	29	19	29	34
Gramineous Herbage—Per Cent. (by weight) in Total Produce.						
1863	69·85	62·21	89·43	91·72	86·83	80·17
1867	62·46	69·99	76·69	94·99	94·99	77·26
1872	67·92	47·95	92·08	99·05	92·77	79·93
1877	71·15	74·38	94·65	98·90	87·81	85·20
Average of the 4 years	67·85	61·03	87·96	95·91	90·78	80·64
Leguminous Herbage—Per Cent. (by weight) in Total Produce.						
1863	9·59	29·42	0·13	0·01	0·13	6·85
1867	5·73	12·04	0·16	0·01	0·39	2·83
1872	9·17	46·26	0·02	0·01	1·36	10·17
1877	9·54	19·71	0·41	0·00	0·76	4·68
Average of the 4 years	8·01	22·06	0·18	0·01	0·66	6·38
Miscellaneous Herbage—Per Cent. (by weight) in Total Produce.						
1863	22·76	11·37	11·44	8·27	11·04	12·98
1867	31·81	29·47	22·15	5·10	4·61	18·91
1872	22·91	11·69	7·90	0·94	5·87	9·90
1877	20·31	11·91	4·94	1·00	11·43	10·12
Average of the 4 years	24·44	15·91	11·86	4·08	8·24	12·98
Gramineous Herbage—Lbs. per Acre.						
1863	2096	2796	5661	6325	5080	4431
1867	2061	3616	4127	5511	6739	4211
1872	1116	2027	5210	7075	5765	4239
1877	1652	3793	5130	7490	5495	4632
Average of the 4 years	1743	2808	5182	6851	5767	4430
Leguminous Herbage—Lbs. per Acre.						
1863	302	1125	8	1	7	281
1867	191	573	9	1	25	160
1872	181	1705	1	1	55	390
1877	302	699	25	0	43	195
Average of the 4 years	202	1026	11	1	43	257
Miscellaneous Herbage—Lbs. per Acre.						
1863	686	503	733	586	631	630
1867	1060	1269	1246	296	422	660
1872	377	504	647	67	365	352
1877	480	606	290	153	715	451
Average of the 4 years	653	721	681	276	536	573
Total Mixed Herbage—Lbs. per Acre.						
1863	3082	4424	6402	7114	5718	5342
1867	3332	4458	5382	5808	7186	5233
1872	1644	4236	5858	7143	6215	4980
1877	2364	5100	5445	7643	6256	5401
Average of the 4 years	2569	4555	5774	6928	6345	5239
Average 10 years 1866-75	2303	3653	5711	6739	6407	5037

TABLE XXXIV.—Abstract of meteorological conditions of the four seasons in which 1866–8, 1871–2, and 1876–7; and comparison of each

	Monthly.							
	July.	August.	September.	October.	November.	December.	January.	February.
RAINFALL AT ROTHAMSTED.—INCHES.								
Average 22 years 1855–6 to 1876–7	2·56	2·45	2·64	2·13	2·20	2·18	2·95	1·88
1861–1862	2·19	0·89	1·63	1·46	2·99	1·58	1·77	0·60
1866–1867	3·01	2·44	4·10	1·92	2·16	2·70	2·46	1·94
1871–1872	4·00	0·77	4·07	1·79	0·85	1·43	4·82	1·47
1876–1877	1·46	2·96	0·02	1·92	4·20	0·42	0·99	2·10
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	+0·63	−1·56	−1·01	−1·67	+1·79	−0·60	−1·08	−1·08
1867	+0·45	+0·99	+1·46	−1·31	−0·04	+0·52	−0·29	+0·28
1872	+1·44	−1·68	+1·43	−1·34	−1·64	−0·76	+1·83	−0·19
1877	−1·10	+0·53	+2·38	−1·81	+2·00	+3·42	+2·14	+0·44
RAINFALL AT ROTHAMSTED.—NUMBER OF DAYS WHEN 0·01 INCH, OR MORE, FELL.								
Average 22 years 1855–6 to 1876–7	12	13	14	16	15	15	16	13
1861–1862	21	11	14	23	20	14	16	7
1866–1867	13	16	24	11	12	15	12	11
1871–1872	18	8	13	10	12	13	21	16
1876–1877	11	14	20	15	20	27	26	19
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	+9	−5	0	−3	+5	− 1	0	−6
1867	0	+3	+10	−5	−3	0	− 4	−2
1872	+6	−5	− 1	−6	−3	− 2	+ 5	+3
1877	−1	+1	+11	−1	+5	+12	+10	+5
MEAN MAXIMUM TEMPERATURE AT GREENWICH (FAHRENHEIT DEGREES).								
Average 22 years 1855–6 to 1876–7	76·6	73·6	67·9	59·0	48·4	44·5	44·0	46·4
1861–1862	72·3	73·6	69·3	64·1	47·3	45·9	43·9	46·5
1866–1867	72·6	69·4	68·1	59·2	50·5	47·6	39·5	50·7
1871–1872	72·6	73·1	67·5	58·6	47·3	42·1	46·3	51·7
1876–1877	77·7	74·5	65·2	60·2	49·9	48·6	49·5	50·4
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	−4·5	+2·0	+0·4	+3·1	−1·1	+1·4	−0·1	+0·1
1867	−4·2	−4·2	−2·8	−0·8	+2·1	+3·1	−4·5	+4·3
1872	−4·2	+4·5	−0·4	−0·4	−0·5	−2·3	+2·3	+5·3
1877	+0·9	+0·9	−2·6	+1·2	+1·5	+4·1	+5·5	+4·0
MEAN MINIMUM TEMPERATURE AT GREENWICH (FAHRENHEIT DEGREES).								
Average 22 years 1855–6 to 1876–7	53·2	53·2	49·5	43·9	36·6	35·0	33·7	34·6
1861–1862	53·6	53·8	48·2	47·7	34·1	36·0	34·3	36·7
1866–1867	52·5	52·3	50·6	46·7	39·0	37·4	29·5	39·5
1871–1872	54·0	52·5	50·3	44·9	36·7	34·3	37·0	39·3
1876–1877	56·1	54·2	48·9	46·9	39·4	39·5	38·6	39·0
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	+0·1	+0·6	−1·3	+3·8	−2·5	+1·0	+0·6	+2·1
1867	−0·8	−0·9	+1·1	+1·8	+1·4	+2·4	−3·2	+4·9
1872	+0·7	+0·6	+0·9	−0·0	−3·9	−0·8	+3·3	+4·6
1877	+2·8	+1·0	−0·6	+3·0	+1·7	+4·5	+3·1	+3·4
MEAN TEMPERATURE AT GREENWICH (FAHRENHEIT DEGREES).								
Average 22 years 1855–6 to 1876–7	62·5	61·9	57·4	50·6	42·2	40·0	38·9	40·1
1861–1862	60·9	62·2	57·1	54·9	40·8	41·0	39·0	41·1
1866–1867	61·0	59·4	56·4	51·3	44·3	42·9	34·2	44·7
1871–1872	61·7	60·8	57·4	49·4	37·6	38·3	41·9	44·8
1876–1877	65·0	62·9	55·8	52·7	44·0	44·3	43·1	44·0
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	−1·6	+1·4	−0·3	+4·3	−1·5	+1·0	+0·1	+1·0
1867	−1·5	−2·4	−1·0	+0·7	+2·0	+2·9	−4·7	+4·6
1872	−0·8	+0·9	0·0	−1·2	+4·7	−1·7	+3·4	+4·7
1877	+2·5	+1·1	−1·6	+2·1	+1·7	+4·3	+4·2	+3·9
MEAN RANGE OF TEMPERATURE AT GREENWICH (FAHRENHEIT DEGREES).								
Average 22 years 1855–6 to 1876–7	21·6	20·4	18·3	14·2	11·8	9·6	9·8	11·4
1861–1862	18·9	21·9	20·1	16·4	13·3	9·9	9·6	9·8
1866–1867	20·1	17·1	14·3	13·7	12·5	10·2	11·0	11·2
1871–1872	19·6	24·2	17·2	15·7	10·4	9·0	9·2	12·5
1876–1877	21·6	20·3	16·4	13·3	11·6	9·1	13·7	12·4
More+ or less− than average of 22 years 1855–6 to 1876–7: 1862	−2·7	+1·4	+1·8	+1·6	+1·4	+0·3	−0·2	−1·6
1867	−1·5	−3·3	−3·9	−2·3	+0·7	+0·6	+1·2	−0·2
1872	−0·0	+3·9	−1·1	+1·9	−1·4	−1·6	−0·6	+1·1
1877	0·0	−0·1	−1·9	−1·3	−0·2	−0·5	+3·9	+1·0

complete botanical separations of the mixed produce were conducted; viz.: 1861–2, with the average of 22 years, 1855–6 to 1876–7.

Monthly (continued).				12 months, July to June, Inclusive.	4 months, July, August, September, October.	4 months, November, December, January, February.	4 months, March, April, May, June.	3 months, April, May, June.	2 months, April and May.
March.	April.	May.	June.						
Rainfall at Rothamsted.—Inches (continued).									
1·77	1·97	2·16	2·40	27·97	10·73	8·42	8·30	6·53	4·13
3·08	2·84	2·81	3·41	27·33	7·17	7·94	12·22	9·16	5·75
2·17	2·62	2·35	1·06	31·13	12·37	9·36	9·40	7·23	6·17
2·15	1·63	2·69	2·09	29·62	10·63	8·13	9·79	7·01	4·62
2·55	2·76	2·62	1·43	37·83	10·38	11·29	9·56	7·01	5·56
+1·29	+0·87	+0·75	+1·01	−0·04	−3·61	−0·95	+2·92	+2·63	+1·43
+0·40	+0·85	+1·10	−1·34	+3·16	+1·29	+0·47	+1·10	+0·70	+2·04
+0·38	−0·34	+0·73	+0·69	+0·65	−0·15	−0·66	+1·46	+1·08	+0·39
+0·78	+0·79	+0·98	−0·97	+3·96	+0·20	+2·40	+1·26	+0·48	+1·46
Rainfall at Rothamsted.—Number of Days when 0·01 inch, or more, fell (continued).									
14	11	12	12	163	55	50	49	35	22
18	14	18	16	182	59	57	66	48	32
12	18	15	10	170	65	50	55	43	28
10	15	18	15	164	48	52	56	46	31
13	13	10	7	217	65	91	61	36	31
+4	+3	+6	+4	+19	+ 4	− 2	+17	+13	+ 9
−2	+3	+3	−2	+ 7	+10	− 5	+ 6	+ 4	+10
−4	+2	+6	+3	+ 1	− 9	+ 3	+ 7	+11	+ 8
+9	+2	+6	−5	+54	+19	+39	+12	+ 3	+ 6
Mean Maximum Temperature at Greenwich (Fahrenheit degrees) (continued).									
49·9	59·4	64·0	71·4	58·7	69·3	43·3	60·9	64·6	61·3
50·0	57·5	66·4	67·1	58·8	70·1	42·9	60·3	63·7	57·0
44·8	58·7	64·7	70·2	57·6	68·3	37·1	59·5	64·6	61·7
52·1	59·3	62·1	71·3	58·9	69·2	45·9	61·6	64·3	60·7
49·3	54·3	59·1	74·4	59·4	69·4	42·6	59·3	62·6	56·7
+0·1	−0·9	+2·4	−4·3	+0·1	+0·3	+0·1	−0·6	−0·9	+0·6
−5·4	+0·3	+0·7	+1·2	−1·1	−1·0	+1·9	−1·4	−0·1	+0·3
+3·4	+0·9	−1·9	−0·1	+0·2	−0·1	+0·7	−0·4	−0·4	−0·5
−0·6	−4·1	−4·9	+3·0	+0·7	+0·1	+3·3	−1·6	−2·0	−4·5
Mean Minimum Temperature at Greenwich (Fahrenheit degrees) (continued).									
34·9	39·6	43·6	50·2	42·4	50·0	34·0	42·1	44·5	41·6
32·4	41·7	47·9	49·3	43·5	52·3	33·3	44·3	46·3	44·5
33·0	42·3	44·7	49·1	42·9	50·3	35·9	42·5	45·4	42·5
37·7	40·1	42·5	50·0	42·6	50·2	35·9	42·5	44·7	41·4
34·1	39·6	41·1	51·5	43·6	51·6	36·4	41·4	44·0	40·4
+3·6	+2·1	+4·2	−0·9	+1·1	+0·3	+0·3	+2·3	+1·8	+3·3
−1·9	+3·7	+1·1	−1·1	+0·4	+0·3	+0·9	+0·7	+0·9	+1·4
+2·3	+0·5	−1·1	−0·2	+0·4	−0·0	+0·4	+0·9	−0·2	−0·3
−0·8	−0·1	−2·5	+1·3	+1·4	+1·5	+3·4	−0·5	−0·5	−1·3
Mean Temperature at Greenwich (Fahrenheit degrees) (continued).									
41·6	47·6	52·4	58·9	49·5	58·1	40·3	50·1	53·0	50·0
42·1	48·4	53·4	56·3	50·1	59·0	40·5	50·8	53·4	51·9
37·7	49·0	53·4	59·1	49·4	57·0	41·5	49·6	53·4	51·2
49·6	49·3	50·9	59·5	49·2	58·3	40·5	50·8	52·3	49·6
40·6	49·6	49·7	61·4	50·7	59·1	43·9	49·1	51·9	47·2
+1·5	+0·9	+3·0	−2·6	+0·8	+0·9	+0·2	+0·7	+0·4	+1·3
−3·9	+1·4	+1·0	−0·8	−0·1	−1·1	+1·2	−0·5	+0·5	+1·2
+3·0	+0·7	−1·3	+0·3	+0·4	+0·2	+0·2	+0·7	−0·2	−0·4
−0·8	−2·0	−2·7	+2·5	+1·2	+1·0	+3·6	−1·0	−1·1	−2·9
Mean Range of Temperature at Greenwich (Fahrenheit degrees) (continued).									
14·6	18·9	20·4	21·1	16·1	18·9	10·7	19·7	20·1	19·7
11·8	15·8	19·5	17·8	15·3	19·3	10·6	19·9	17·4	17·1
11·5	16·4	20·0	21·1	14·9	16·0	11·2	17·3	19·2	16·2
19·7	19·3	19·7	21·3	16·1	19·2	10·0	19·0	20·1	19·4
15·2	14·8	18·0	22·9	15·7	17·9	11·5	17·7	18·6	18·4
−3·6	−3·1	−1·9	−3·3	−0·8	+0·5	−0·1	−2·8	−2·7	−2·6
+2·1	−2·6	−2·4	0·0	−1·2	−2·3	+0·6	−1·4	0·0	−1·5
−1·1	+0·3	−0·7	+0·5	0·0	+0·4	−0·7	+0·3	0·0	−0·3
−0·9	−4·1	−2·4	+1·9	−0·4	−0·9	+0·9	−1·0	−1·5	−3·3

incidental characters of the seasons merely, and those properly attributable to the artificial conditions induced by exhaustion, or those supplied by manure. It is proposed, therefore, before entering upon the consideration of the botany of the different plots, as illustrated by the results of the detailed botanical separations, to point out what were the characters of the seasons themselves in which the separations were made, and what was the general character of their influence on the vegetation of the different plots.

The results given in Tables XXXIII. and XXXIV. supply the chief basis for the illustrations which follow in relation to these points.

Table XXXIII., p. 1189, gives the total number of species found, and both the per cent. by weight in the total produce, and the lbs. per acre, of the gramineous, the leguminous, and the miscellaneous herbage, respectively, in each of the four seasons of complete botanical separation, on each of the five very characteristically differently manured plots which were selected for illustration when considering the characters of the seasons of the highest and of the lowest productiveness (Part I., Phil. Trans., 1880, p. 399). There is also given the total amount of mixed herbage per acre, on each plot, in each of the four seasons, and the average for each plot, over the four years of separation and over the 20 years 1856–1875 inclusive. From these results some idea can be formed of the general and comparative characters of each of the four seasons, so far as activity of vegetation or productiveness merely is concerned. It should be explained that, for the purposes of this very summary statement of the botanical characteristics of the produce of the four different seasons, the "undetermined" herbage, if any, that is the amount which could not be referred to individual species, has, nevertheless, after careful examination been apportioned by judgment among the three main divisions given in the table—namely, the gramineous, the leguminous, and the "miscellaneous" herbage.

Table XXXIV., pp. 1190-1191, shows some of the meteorological conditions of the four seasons of the complete botanical separations. The same particulars as to rainfall and temperature are given, and in the same form, as in the tables illustrating the characters of the seasons of the highest and of the lowest productiveness (Part I., pp. 400–1). They are given for each of the months from July to June separately, and for series of months collectively, for the average of the 22 years, 1855-6 to 1876–7 inclusive, and for each of the four years (July to June inclusive), 1861–2, 1866–7, 1871–2, and 1876–7. The variations of each of the four seasons + or − the average of the 22 are also given.

Season 1861–2.

There was a considerable deficiency of rain throughout the autumn of 1861 and the winter of 1861–2, excepting in November, when there was a considerable excess. The autumn and winter were also warmer than the average, excepting again in November, when, with the excess of rain, there were also prevailing low temperatures, the month

being generally inclement. The autumn dryness would appear not to have been favourable for the second growth of 1861; but there had been a considerable excess of rain in June and July, and the second crops were estimated to be rather above the average on all the plots, excepting on that with the highest quantity of ammonia-salts. Thus, both as to previous growth and measurable meteorological factors, the conditions antecedent to spring growth in 1862 would not seem to have been favourable to luxuriance. In each of the months of March, April, May, and June, however, there was more than the average amount of rain; and the excess was the greatest, and considerable, in March, June coming next in this respect, so far favouring both an early start and protracted luxuriance. The mean temperatures of March, April, and May were also above the average; due in March and April to high minimum readings, and in May to both high maximum and minimum readings. In June, however, with the excess of rain, there was considerably lower than the average maximum, and lower also than the average minimum temperatures, giving, upon the whole, a wet and cold month at the time when the mixed herbage should mature.

Thus, with antecedent conditions certainly not specially favourable, but, on the other hand, not specially unfavourable, the period of most active vegetation was, both as to moisture and temperature, propitious for luxuriance, whilst the concluding period was not suitable for maturation.

Under these circumstances, the crop of 1862 was considerably over average without manure, with mineral manure alone, and with mineral manure and ammonia-salts; but it was below the average with mineral manure and nitrate of soda.

Without manure the excess was in the largest proportion in the gramineous herbage, but partly, also, in that furnished by the leguminous and miscellaneous plants.

With mixed mineral manure, including potass, the increase over the produce without manure was in the grasses and the Leguminosæ, whilst miscellaneous plants were in reduced amount, and the increase compared with the average of the four on the same plot was entirely in the Leguminosæ.

With the mixed mineral manure and the smaller quantity of ammonia-salts the increase was mainly in the grasses, but considerably, also, in miscellaneous herbage, especially in *Rumex Acetosa*. With the mixed mineral manure and the double quantity of ammonia-salts the yield of grasses was less than on the average of the four years, but, judging from the amount of total produce, probably more than the average of the 20 years; and there was a considerable excess of miscellaneous plants, and again more especially of *Rumex*. On both these mineral and ammonia-plots *Conopodium denudatum* and *Achillea Millefolium* were also abundant.

With the mixed mineral manure and nitrate of soda the *deficiency*, compared with the average, was chiefly in the grasses, the Leguminosæ also being in very small amount; but the miscellaneous plants were fairly abundant, and here again the chief weed was *Rumex Acetosa*, *Conopodium* coming next, and *Ranunculus* (*repens* and *bulbosus*) third.

Thus, especially on the plots with ammonia, the wet and warm-growing period was

favourable to the luxuriance of gramineous herbage, the freer growing and comparatively surface-rooting and moisture-loving species there prevailing; whilst on the plot with nitrate of soda where, besides the free-growing and chiefly surface-rooting *Poa trivialis* and *Lolium perenne*, the deeper-rooting and comparatively drought-resisting *Bromus mollis* had already established predominance, the gramineous herbage, as a whole, was not specially luxuriant. The season was not unfavourable for the Leguminosæ on the plots where the grasses were not forced by nitrogenous manures; but where they were so the Leguminosæ were much discouraged. Miscellaneous plants were a good deal favoured. Where there was no nitrogenous manure *Rumex*, *Plantago*, and *Ranunculus* were very prominent; where there was nitrogenous manure and coincident free growth of grasses, *Rumex* was still the most prominent weed, *Conopodium denudatum* coming next, and with ammonia-salts *Achillea Millefolium*, but with nitrate of soda *Ranunculus* (*repens* and *bulbosus*) came third.

The notes made on the crop before and at the time of cutting show that the herbage generally was characterised by abundance of foliage, dense undergrowth and backwardness, with comparatively little tendency to form stems or to produce flower or seed.

The season of 1862 was, therefore, upon the whole, favourable for luxuriance of the freer growing species, yielding, however, for the most part, leafy and immature produce.

Season 1866–7.

In the preceding year, 1866, the first crops had been, upon the whole, over average, and the second crops were estimated to be so; but, owing to the wetness of the autumn, they had been cut and left to decay on the land. There had been a considerable excess of rain in June, July, August, and September, 1866, with on the average low temperatures. The concluding three months of 1866 were, however, upon the whole, deficient in rain, with higher than the average temperatures, though in November a good deal of rain fell within a short period, causing floods in some localities. In January, 1867, the fluctuations were very great. Extreme cold and heavy falls of snow alternated with rapid thaws, warm weather, heavy gales, and a good deal of rain, though in the aggregate there was not an excess of fall, but there was a considerable defect in temperature. The last week of January and almost the whole of February were unusually warm, with, at the beginning of February, a large amount, and during the month an excess, of rain. March, on the other hand, was almost to the conclusion very cold and wintry, with a good deal of snow. There was an excess of fall during the month, and on the average very low temperatures, and vegetation was much checked. April and the beginning of May were very unsettled—stormy, rainy, and changeable as to temperature, but on the whole warmer than the average. Later in May, besides some very warm, there was a longer period of extremely cold weather, with a dry atmosphere and frosty nights, vegetation being again much checked, though, during the month, both the fall of rain and the temperatures were above average.

Lastly, June showed considerable deficiency of rain, was very changeable as to temperature, but upon the whole colder than the average.

Thus the season of 1866–7 was marked by very great fluctuations. The early winter was generally warmer than usual with about the average fall of rain. Then came intervals of severe frost, snow, and heavy gales, which were followed by several weeks of warm weather, with a good deal of rain—conditions favourable for an early start of vegetation. But the early spring was very wintry and stormy, and growth was much checked. The remainder of the growing period was very changeable as to temperature, and frequently wet and stormy. June, the maturing period, though changeable, was upon the whole dry, but not so warm as usual.

With such extremely varying climatal conditions we could hardly expect other than irregularity of result with very different plants, and with very different manuring conditions. Without manure especially, and with purely mineral manure in a less degree, there was more than the average amount of produce. And, exactly reversing the results of 1862, there was with the mineral manure and ammonia-salts a considerable deficiency, and with the mineral manure and nitrate of soda a considerable excess, of produce, compared with the average of either the four years or the 20.

Without manure, and with mineral without nitrogenous manure, the excess of produce over the average was not proportionally great in the grasses, leguminous herbage was deficient, but miscellaneous plants contributed an unusually large proportion of the crops. Without manure by far the most prominent weed was *Plantago lanceolata*. *Luzula campestris*, *Pimpinella Saxifraga*, *Conopodium denudatum*, *Ranunculus* (*repens* and *bulbosus*), and *Rumex Acetosa* were also prominent. With the purely mineral manure *Conopodium denudatum* and *Rumex Acetosa* each contributed about one-third of the miscellaneous herbage; *Achillea Millefolium* was also prominent; and, as without manure, *Luzula campestris*, *Pimpinella Saxifraga*, and *Plantago lanceolata*, were somewhat so, but in a much less degree.

Owing to the wetness of February and the general inclemency of March, the sowing of the ammonia-salts was not commenced until March 11; the process was even then interrupted by snow, and the plots here referred to were not sown until March 21.

With the mineral manure and the smaller quantity of ammonia-salts there was a considerable deficiency of total produce compared with the average. This deficiency was due to a generally restricted growth of the grasses; probably accounted for in part by the adverse weather of March, and in part by the less effect or even damage done by the late sown ammonia-salts, under such conditions. Leguminosæ were scarcely represented. But, again, miscellaneous herbage was unusually abundant. Among the grasses the poor and meagrely yielding, but hardy *Festuca ovina* contributed the most, *Agrostis vulgaris*, *Poa pratensis*, and *Holcus lanatus* a good deal; whilst the more freely yielding *Dactylis* and others were in but small amount. Among the miscellaneous plants, *Rumex Acetosa* and *Conopodium denudatum* contributed nearly nine-tenths of the whole; *Achillea Millefolium* being next in prominence.

With the mineral manure and the double amount of ammonia-salts, there was again great deficiency in the yield of the grasses; but here *Dactylis glomerata* was by far the most prominent, and gave a large amount of both leafy and stemmy growth. *Agrostis vulgaris* came second in prominence, and both *Alopecurus pratensis* and *Poa pratensis* were fairly represented. With this predominance of a few free-growing grasses, the amount of miscellaneous herbage was considerably less than half as much as on the same plot in 1862, and only about a quarter as much as on the plot with the smaller quantity of ammonia-salts in the same year, 1867. The weed which maintained the most prominent place in the struggle was *Rumex Acetosa*; *Conopodium denudatum* coming next. Only two other species were found in the sample, and these in only very insignificant amount.

The nitrate of soda was not sown until April 10, when growth would be fairly established, so that the loss by drainage which would otherwise result from the excess of rain would be checked, and active vegetation favoured. The excess instead of deficiency of produce which was thus obtained with the mineral manure and nitrate of soda consisted almost exclusively of gramineous herbage. *Poa trivialis* contributed about one-third, and *Bromus mollis* more than one-sixth of the whole produce; whilst *Lolium perenne*, *Dactylis glomerata*, *Avena flavescens*, and *Holcus lanatus* were also in fair proportion. The crop was characteristically very stemmy, the most so of any in the series, and *Bromus* especially was shedding ripe seeds. It will be remembered that whilst June, the maturing month, was in 1862 very wet and unusually cold, it was in 1867 very dry, and though not so warm as usual, by no means so cold as in 1862. Hence, the grasses which had been brought so rapidly forward under the influence of the nitrate of soda were unable to ripen. With this free and forward growth of grasses, leguminous plants occurred in quite insignificant amount, and miscellaneous species in less than average quantity. Of the latter, *Conopodium denudatum*, *Anthriscus sylvestris*, and *Rumex Acetosa* were in the greatest prominence.

Thus, with the very fluctuating climatal characters of the season of 1867, we have, with the varying floras, and the varying and irregularly and late-sown manures, widely varying characters of growth. There was in some cases an excess, and in others a deficiency of produce compared with the average. The different gramineous species were very differently affected; Leguminosæ were generally deficient, and miscellaneous plants were for the most part in excess. The growth was, upon the whole, much more characteristically leafy than stemmy; but with nitrate of soda it was very characteristically stemmy.

Season 1871–2.

Between the separation season of 1867 and that of 1872 a remarkable period intervened, so far as the growth on the experimental plots was concerned. One of those four intervening years (1869) was the one of highest productiveness in the whole series; another (1868) came only second in this respect; and a third (1870) gave by

far the lowest produce in the entire series. It happens, therefore, that these three out of the four intermediate seasons came under detailed discussion when considering the seasons of highest, and of lowest, productiveness, in Part I. of this paper. As the conditions and results of growth referred to undoubtedly exercised considerable influence on the struggle from year to year, it seems desirable to make brief reference to the characters and results of those four seasons, before describing those of 1872, the season of separation itself.

The first of the four seasons, 1868, was on the whole the second in productiveness throughout the series. "Luxuriant early growth was followed by both unusual drought and unusual heat, yielding quantity by virtue of high development and maturation, as distinguished from succulence and immaturity." And the heavy and ripe first crops were succeeded by very meagre second growth.

The season of 1869 was the one of highest productiveness of all throughout the series. "The period prior to that of most active above-ground growth had brought the herbage into an unusual state of forwardness; when .... abundance of rain, with, upon the whole, low temperatures, gave great luxuriance, but comparatively leafy, succulent, and immature produce." And, as under the very different conditions in 1868, the second growth was considerably below average.

The season of 1870 was the one of lowest productiveness throughout the series. "The winter and early spring of 1870 had not upon the whole been deficient in rain, but the period had been extremely variable as to temperature, frequently very inclement; and on the average colder than usual. The herbage was, from these causes, very backward at the commencement of the active growing period. April, May, and June followed with a great deficiency of rain, very high day and low night temperatures, yielding very stunted, and prematurely ripened produce." The drought and heat still prevailing several weeks after the cutting of the first crops, the second crops (which were cut and spread on the plots) were also very meagre.

The season of 1871 gave more than the average produce of first crops under all conditions of manuring. The second crops were also uniformly above the average, and on the nitrate of soda plots very considerably so. The greater part of the winter, 1870–1, had been extremely severe, with a great deal of snow, and very cold winds. At the commencement of the growing time the plots were very bare and backward. With the exception of the latter half of April, that month, May and June were unusually cold, and there was an excess of rain in April and June, but a deficiency in May. June especially was very unseasonably cold and wet. The dryness of May checked undergrowth, and favoured the formation of flowering stems; but with the wetness of June a kind of second growth succeeded; and when the crop was cut there was, besides the early-formed flower stems and some seed, a large amount of leafy matter produced, much contributing to the weight of the crops.

Thus the first two years since the botanical separations of 1867 had given the two heaviest first crops in the series, the third the lightest, and the fourth more than the

average. The heavy crop of the first year had been characterised by great stemminess and maturity, and the heavy ones of the second and fourth years by luxuriant leafy growth. The first (1868), and the third and smallest crop (1870), were the result of seasons of drought and heat; in the case of the heavy crop the drought and heat coming late, and succeeding upon previous luxuriance, and in the case of the light crop commencing early, and succeeding upon previous backward conditions.

Although the freer growth of the wetter seasons must obviously affect the relative predominance of the different components of the mixed herbage, seasons of heat and drought, like those of 1868 and 1870 (though they were so very different from one another), have a much greater influence in this respect. In fact, there is no doubt that the distribution and predominance of species in 1872 was influenced, not only by the continuous application of the different manures from year to year, but materially also by the characters and the growth of the several preceding seasons, especially by those of the years of drought and heat.

We come now to the characters and the growth of the season of 1872 itself. July 1871 was characterised by a considerable excess of rain and low temperatures; August and the first half of September were warm and dry; but the end of September was very wet, cold, and stormy. October, November, and December were considerably deficient in rain, with lower than average temperatures. Mr. Glaisher states, indeed, that November and the first half of December were characterised by the longest continuance of low temperatures in the century for that period of the year. After the long continued dry and very cold weather, the three months from the middle of December 1871 to the middle of March 1872 were almost continuously very unusually warm, with a considerable excess of rain in January, a deficiency in February, but again some excess in March. The latter half of March was exceedingly variable as to temperature; and this character prevailed until early in May; periods of unusually high and unusually low temperatures alternating, the higher, however, prevailing; whilst April was deficient in rain. Then followed about five weeks of mostly cold and cloudy weather with hoar frosts and frequent rain; the fall being in excess in both May and June, as it had been also in March. The last fortnight or so before the cutting of the grass was, however, warmer, and the period included some heavy thunderstorms.

Thus the early winter was dry and extremely cold; next followed nearly three months of prevailing high temperatures for the period, with a sufficiency of rain, so far favouring an early start of growth. Then came some weeks very variable as to temperature, with some deficiency of rain; the remainder of the growing period was unseasonably cold and cloudy, but with a sufficiency of rain; and, finally, the maturing period was warm, but interspersed with heavy showers.

These very changeable characters of season are obviously those of fair luxuriance, but of varying tendency to stem and seed formation, and to maturation, according to the already established botanical and other characteristics of the herbage, and the conditions of

manuring supplied. The general result was less than average produce with defective conditions of manuring, but over average with high manuring where the nitrogen was applied as ammonia-salts, but less than average where it was applied as nitrate of soda.

Without manure the produce was very considerably deficient. The herbage was short, even, and scanty in development of both leaf and stem. Among the grasses, the hardy and surface- and fibrous-rooting *Festuca ovina* was the first, and the creeping-rooted *Agrostis vulgaris* the second, in order of predominance.

With the purely mineral manure there was, notwithstanding a considerable deficiency of grasses, more than average total produce, due to the growth of a very unusual proportion and amount of leguminous herbage, which consisted almost exclusively of *Lathyrus pratensis*. There was a fairly mixed, though deficient, undergrowth of grasses, *Festuca ovina* and *Agrostis vulgaris* being, however, by far the most prominent. Miscellaneous plants were in less amount than usual; the most prominent being *Achillea Millefolium*, which contributed nearly half; whilst *Luzula campestris*, *Conopodium denudatum*, and *Rumex Acetosa* were the next in prominence.

With the mixed mineral manure and the smaller quantity of ammonia-salts scarcely the average produce was yielded. The grasses were in about, or perhaps over, average amount. Leguminosæ were almost absent. Miscellaneous species were in less than average quantity. By far the most prominent grass was *Poa pratensis*—*Agrostis vulgaris*, *Dactylis glomerata*, *Avena elatior*, *Festuca ovina*, and *Holcus lanatus* being also fairly prominent. The growth was characterised by coarseness of both leaf and stem. The most prominent weed was *Rumex Acetosa*, which contributed nearly two-thirds of the miscellaneous herbage. The only other miscellaneous plants occurring in any noticeable quantity were *Conopodium denudatum* and *Achillea Millefolium*.

With the mixed mineral manure and the double quantity of ammonia-salts there was considerably more than average produce, and the excess was exclusively in grasses. Nearly two-fifths of the whole produce was made up of the free-growing and heavy-yielding *Dactylis glomerata*; and most of the remainder consisted of *Agrostis vulgaris*, *Alopecurus pratensis*, *Avena elatior*, *Poa pratensis*, and *Holcus lanatus*, in the order enumerated, but in fairly equal proportions. The herbage comprised therefore a fair quantity of a number of free-growing, and in some cases good meadow grasses. The growth was, however, very luxuriant and coarse. The only weed in any prominence was *Rumex Acetosa*.

With the mixed mineral manure and nitrate of soda there was rather less than average produce. The grasses were in about average amount. Leguminosæ were in more than average, but still in insignificant quantity. Miscellaneous plants were in considerably less amount than usual. Nearly half the gramineous herbage was made up of *Bromus mollis*, which was in full flower early in June; *Poa trivialis* was also very prominent. In much less quantity followed *Avena flavescens*, *Lolium perenne*, *Alopecurus pratensis*, *Holcus lanatus*, and *Dactylis glomerata*. The only leguminous

plant in any quantity was *Lathyrus pratensis*. *Anthriscus sylvestris* was the only really prominent weed; *Rumex Acetosa* and *Conopodium denudatum* coming next.

Thus, by virtue of the characters and results of the intermediate seasons since 1867, and especially by the effects of the two years of drought, 1868 and 1870, the distribution of plants on the different plots had become considerably modified. Among the grasses *Festuca ovina* had become very much more prevalent, especially on the less liberally manured plots; as also had *Agrostis vulgaris*, and even so with higher manuring. *Festuca ovina*, indeed, which had been first in predominance on only two plots in 1862, and on eight in 1867, was so on 13 in 1872; *Agrostis vulgaris* again, which had been second on seven plots in 1862, and on eight in 1867, was so on 14 in 1872. With mineral manure and ammonia-salts the free-growing *Dactylis* or *Poa pratensis*, had, however, maintained the first place; *Agrostis vulgaris* and some others being also prominent, but *Festuca ovina* much less so. *Bromus mollis*, which had seeded very freely in 1870 and 1871 on the plot with mineral manure and nitrate of soda, was again first with that mixture in 1872, *Poa trivialis* coming second on that plot, but having considerably gone down on the deficiently manured and ammonia manured plots. A few other moderately good grasses also maintained a place. Leguminous herbage had only gained ground materially with mineral manure alone. Miscellaneous herbage had been generally reduced. The plants which had maintained their ground the most prominently were *Rumex Acetosa*, *Achillea Millefolium* (which had indeed considerably increased), and *Conopodium denudatum*.

To conclude,—with considerably modified floras and vegetation on the differently manured plots, due materially to recent seasons of luxuriance or drought, or both, and with very variable weather in the season of separation itself (1872), the greater part of the growing period being more favourable for luxuriance than maturation, and the ripening weather being late, broken by heavy showers and of short duration, we have very variable characteristics of produce, according to the conditions of manuring supplied.

Season 1876–7.

In the last section it has been shown that the flora and vegetation of the different plots had become considerably modified by the characteristics of the seasons prior to the separation year of 1872; and that the most potent of these influences had been the occurrence of seasons of drought and heat; whilst the character of the period of growth itself of the first crop of 1872 had been that of variableness, thus differently affecting the mixed herbage on the differently manured plots according to the conditions which had been induced under the influence of the several preceding seasons.

As to amount of produce, the first crops of 1872 had been below average with defective manuring, but average, or above average, with liberal manuring. After the cutting of the first crops there was a considerable amount of rain; the growth was somewhat dense, and the second crops were pretty uniformly over average.

The winter of 1872–3 was upon the whole very wet; in the earlier part of it warmer than the average, but in February, and also in March, there were deep snows and sharp frosts. Then followed a dry grass-growing season, with, for the most part, lower than average temperatures. The result was backward growth and deficient first crops of hay under every condition of manuring, and very considerable deficiency under most conditions. The grasses were dwarfish, yielding but little stem and rather thin undergrowth, thus favouring the luxuriance of a few strong growing weeds, such as *Rumex Acetosa*, *Centaurea nigra*, and *Achillea Millefolium*; whilst leguminous herbage was less prominent than usual. After the removal of the first crops there was more than the average amount of rain, there was fairly dense growth on most of the plots, yielding two cuttings, one in the middle of August and the other in the middle of October, the produce in both cases being spread on the respective plots. On many plots *Festuca ovina* contributed a large proportion of the dense grassy undergrowth.

The winter and early spring of 1873–4 were upon the whole considerably warmer than usual, but with a considerable deficiency of rain, so that vegetation remained very backward. Then followed continued drought, with unusual cold both day and night, and the already backward herbage was very materially damaged, yielding not only checked and stunted, but really injured crops. Indeed, the grass-season of 1874 was the second in order of unproductiveness among the first 20 of the experiments, and as such has already been considered in more detail in Part I. of this paper. July was hotter than the average, with, however, a sufficiency of rain; August was dry but cold; September and October were wet, with rather above average temperatures. There was, nevertheless, but little growth after the first cutting, excepting on a few of the highly-manured plots. A second crop was cut in the middle of August, and a third at the end of September, both being spread on the respective plots.

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The winter of 1874–5 was variable, but included a good deal of severe weather, with more than the average fall of rain. There was a deficiency of rain, with lower than average temperatures, in February, March, and April; the period being upon the whole inclement, cold, and dry, and vegetation was accordingly backward. There was an excess of rain in May and June, with at the same time higher than average temperatures. May especially was warm, showery, and genial, stimulating the growth of most species; whilst June improved some, but retarded others, the middle of the month being stormy and sunless. The produce was, on most of the experimental plots, below average; but on a few of those most highly-manured, above average. The wet and warm May was specially favourable to such moisture-loving and surface-rooting plants as *Agrostis vulgaris* and *Poa trivialis*, which came much to the front; and the grasses showed such a dense leafy-growth that the leguminous and miscellaneous species were less prominent than usual. After the cutting of the first crop there was a great excess of rain in July, though with lower than average temperatures in that month, but higher afterwards. The result was that the short yield of the

first crop was succeeded by an exceedingly luxuriant aftermath. Among the grasses on the highly-manured plots, the large free-growing species were the most favoured, and they yielded flower-stems in abundance. On the plots with mineral manure and ammonia-salts *Dactylis glomerata* and *Avena elatior* were specially prominent; and with mineral manure and nitrate of soda many seedlings of *Bromus mollis* were observed. Leguminous and miscellaneous plants were also generally very prolific in flower-stems, and in many cases seeded. At the time of cutting the second crops, before the middle of September, the unmanured and the mineral-manured plots showed great variety of colour owing to the number of species in flower. On the plots heavily dressed with mineral manures and ammonia-salts the general herbage ranged from 9 to 18 inches in height, whilst the flowering stems of the grasses were from 18 inches to 3 feet high, according to the quantity of nitrogenous manure employed. The mineral manure and nitrate of soda, on the other hand, which had yielded the heaviest first crop gave less excessive aftergrowth, and but few flowering stems. Under all conditions as to manure the second cuttings were, however, much heavier than the average; indeed, excepting with the nitrate, generally very heavy.

Owing to the amount of the crops, to the difficulty which had been found in dealing with the second crops without removing them, and to the fact that a period of 20 years had now been completed, during which only the first crops had been removed, it was decided henceforward to cut and remove the second crops whenever practicable; and, accordingly, the heavy second crops of 1875 were so treated.

It is obvious that the removal of the second crops materially affects the condition of the land, and in the case of the deficiently-manured plots tends to much more rapid exhaustion. It is also obvious that, with this change, a new element in the struggle among the components of the mixed herbage is brought into play, or at any rate the effects of an old one are considerably intensified.

The late autumn, winter, and early spring of 1875–6 were, excepting in December and January, very wet; and the two comparatively dry winter months were notably colder than the average. In the middle of April, 1876, there was a very unusually heavy snow fall; and, succeeding upon this unseasonable weather, May and June were both unusually dry and unusually cold. The result was a backward and generally scanty and thin crop, with a deficiency of bottom grass. The leguminous and miscellaneous species, as well as the gramineous, were deficient. It was only with the highest manuring that the weight of produce was average, or over average; the result in these cases being due to a few of the freer-growing species, with comparatively extended root-range, attaining considerable luxuriance under those conditions; whilst, on most of the plots, the amount of produce was much below the average. The first crops were not cut until the end of June. July was both warm and dry, August was warm and wet, and September cold and very wet. The second crops were for the most part patchy; but the wet weather of September brought forward a fair amount of leafy bottom growth. The quantity of produce was, however, very much less than in

1875, and in contrast to the second growth of that season, there was, in 1876, scarcely any tendency to formation of stem, and both leguminous and miscellaneous species were deficient and backward. The crops were cut towards the end of September; but owing to the wetness and coldness of the weather they could not be made into hay and removed, and were, therefore, spread upon the respective plots.

We have now to consider the characters of the season, and the general characters of the produce, of 1877: the fourth and last of the years of complete botanical separation.

In November, December, and January, 1876–7, there was a great excess of rain; the total excess in the three months amounting to about 8 inches. There was again an excess in each of the months of February, March, April, and May; the total excess in these four months amounting to about 2½ inches. With this great excess of rain over seven consecutive months, from the beginning of the winter to May inclusive, there was, at the same time, in the first four months of the period, November to February inclusive, a considerable excess of temperature, both maximum and minimum; but in the next three months, March, April, and May, the temperatures were for the most part unusually low.

Thus, during the winter and spring the soil was saturated with water, and with the warmth as well as wetness of the winter, grass was very green, forward, and promising at the commencement of the usual active growing period; but the cold weather of April and May greatly checked vegetation. About the middle of April piercingly cold and boisterous winds prevailed, and, although they tended to dry the saturated soil, they were otherwise adverse to growth. Early in May the weather was extremely cold, with north-east winds, storms of sleet, and severe night frosts. Almost all species seemed to suffer, and it was not until about the third week of the month that there was genial growing weather, brightening the prospects of the hay harvest, but coming too late entirely to overcome the effects of the previous adverse conditions. Hence, at the commencement of June the mixed herbage generally presented a very backward appearance, grasses were short and benty, with little undergrowth; but, with the abundance of moisture within the soil, and the warm forcing weather of the early part of June, rapid growth then set in, and the mixed herbage thickened surprisingly, and the grasses especially came quickly to maturity. Eventually the weight of produce was over average on most of the experimental plots, and considerably over average on a few of those the most liberally manured. But, as the following comments on the herbage of a few typical plots, and the detailed results given further on will show, there was considerable irregularity in the condition of development of the different components of the mixed herbage.

Without manure, there was about the average total produce, a full number of species, a rather higher than average percentage, and about an average amount of grasses; there was a fair proportion of leguminous species, but less than the average amount of miscellaneous herbage. *Festuca ovina* was the most prominent grass, *Agrostis vulgaris*

coming second, and *Holcus lanatus* third; whilst *Briza media*, *Anthoxanthum odoratum*, and *Lolium perenne* were fairly represented. Of the leguminous herbage, the deep-rooting *Lotus corniculatus* contributed nearly half, and *Lathyrus pratensis* and *Trifolium pratense* most of the remainder. Of miscellaneous species, *Ranunculus* (*repens* and *bulbosus*) and *Plantago lanceolata* together contributed about a third, *Achillea Millefolium*, *Conopodium denudatum*, *Rumex Acetosa*, and *Luzula campestris* making up most of the remainder. The crop was dwarf, both in leaf and stem, and mostly backward; but the miscellaneous species were upon the whole rather more advanced than either the grasses or the Leguminosæ.

With the mixed mineral manure alone there was considerably more than the average quantity of total produce, the grasses being in larger, but the leguminous and miscellaneous species in less percentage as well as less actual amount than usual. As without manure, *Festuca ovina* was by far the most prominent grass, *Holcus lanatus* and *Agrostis vulgaris* together contributing about as much, and *Dactylis glomerata*, *Avena flavescens*, *Anthoxanthum odoratum*, and *Lolium perenne* each contributed several per cent. to the produce. Of the total leguminous growth, *Lathyrus pratensis* contributed more than seven-eighths; of the miscellaneous herbage, *Rumex Acetosa* contributed more than half. Next in order was *Conopodium denudatum*, yielding less than a quarter as much, and five or six other species made up most of the remainder. The crop was dense and moderately tall, with a fair amount of both stem and undergrowth. Among the grasses *Festuca ovina* gave the largest proportion of stem, and *Agrostis vulgaris* the largest proportion of leaf. The herbage was upon the whole more matured than without manure, though the leguminous plants were rather more backward than usual.

With the mixed mineral manure and the smaller amount of ammonia-salts, the weight of produce was more than the average. Nearly 95 per cent. by weight consisted of grasses, less than a half per cent. of leguminous, and less than 5 per cent. of miscellaneous species; the grasses contributing a larger, and the miscellaneous species a much smaller proportion than usual. *Festuca ovina* was again the most prominent grass; but *Poa pratensis*, *Dactylis glomerata*, *Avena elatior*, *Agrostis vulgaris*, and *Holcus lanatus* were also in considerable amount, and the six grasses enumerated contributed nearly 90 per cent. of the total produce. The only weed in any prominence was *Rumex Acetosa*. The crop was heavy and dense, with a large proportion of tall, luxuriant, and matured flowering stems. *Avena elatior* was the most, and *Holcus lanatus* and *Agrostis vulgaris* were the least, advanced of the prominent grasses.

With the mixed mineral manure and the double quantity of ammonia-salts there was much more than the average amount of total produce. There was a smaller number of species than usual. The grasses contributed about 98 per cent. of the whole; no Leguminosæ were found, only four miscellaneous species were observed, and *Rumex Acetosa* was the only one in any prominence. Among the grasses the freely-growing *Agrostis vulgaris*, *Holcus lanatus*, *Avena elatior*, *Alopecurus pratensis*, and *Dactylis glomerata* all greatly exceeded in amount the *Festuca ovina*, which was here in but

small proportion, and was nearly equalled by *Poa pratensis*. Upon the whole the growth was rank and tufty, and the free-growing grasses yielded a considerable amount of flowering stems.

With the mixed mineral manure and the larger quantity of nitrate of soda (equal in nitrogen to the smaller quantity of ammonia-salts) there was scarcely the average weight of total produce. The number of species was lower than usual; the grasses contributed about 88 per cent. of the total weight; the Leguminosæ gave less than 1 per cent.; but the miscellaneous species between 11 and 12 per cent., which was considerably more than the average on that plot. *Poa trivialis* and *Alopecurus pratensis* were by far the most prominent grasses, *Holcus lanatus* and *Dactylis glomerata* coming next, whilst *Bromus mollis* and *Poa pratensis* were also fairly represented. *Lathyrus pratensis* was the only leguminous plant observed. *Anthriscus sylvestris* and *Rumex Acetosa* contributed more than three-fourths of the miscellaneous herbage. The crop on this plot was the most evenly luxuriant, and the most matured, of the series, yielding a large bulk of stem, with comparatively little leaf, and a large proportion of the plants were either in flower or seed, the base of the stems turning brown with ripeness.

Between the years of separation of 1867 and 1872, as far as the influences of season were concerned in modifying the vegetation of the different plots, there had been years of great luxuriance of growth, and years of unusual drought with heat, and it was the latter which had the most marked effect in modifying the struggle established under the different manuring conditions.

Between the years of separation of 1872 and 1877, the influences of season were of a different kind. The first crops of the intermediate years were only average or under average in amount, and those of the second year were not only much under average, but the herbage was really damaged by the dryness and cold of the growing period; whilst in each of the years excepting the third, that period was considerably deficient in rain, and marked by unseasonably cold intervals, much checking vegetation. Nevertheless the *hay-year*, reckoned from July of one year to the end of June of the year of growth, showed in each case excepting that of the second year, an excess of rain over the average, which, however, chiefly affected the aftermath. It is, indeed, obvious that an excess of rain prior to the period of active growth of the first crops may leave the soil and subsoil in such a moist condition as to render the herbage less dependent on the fall of the actual period of growth itself; but, in so far as the excess of rain increases the second crops, the condition of the herbage will be affected for the growth of the succeeding first crops. It happens that, whilst the third and fifth series of autumn crops grown since the separation of 1872 were deficient and variable in character, owing partly to the unseasonable weather of the period, and partly to the previously induced condition of the herbage, the first, second, and fourth seasons gave more or less luxuriant second growth; and the fourth season not only gave the heaviest

second crops of the series of years, but the produce was for the first time removed from the land.

We thus had, prior to the season of separation of 1877, several seasons of more or less ungenial weather for the growth of the first crops, actually damaged herbage, in one case affecting even the second crop, with, in other cases, comparatively luxuriant second growth, and one heavy second crop removed; and such were the conditions preparatory to the growth of the crop to be submitted to botanical analysis. Lastly, the season of separation itself, following these conditions, was characterised by a wet and mild winter and spring, giving early promise; growth was then checked by cold, but eventually luxuriant and heavy crops were obtained, which, however, were very variable in character of development according to the character of the manures employed.

The general result was a tendency to an increased proportion of gramineous herbage, and a diminished proportion, especially of the miscellaneous species, on most of the plots. There was also a tendency to a diminution in the proportion of the leguminous herbage on those plots which had been under the same treatment from the beginning; but a tendency to increase on some where the manures favourable to such plants had not been employed until more recently. Further, with the prevailing wetness of the intervening period, the freer-growing grasses gained ground on those plots where the manures were the most favourable for the luxuriant growth of gramineous herbage.

The foregoing review of the characters of the seasons preparatory to, and during the actual growth of the four crops submitted to detailed botanical separation, will sufficiently show that, independently of the very much more marked influences of the different manures in determining the results of the struggle between the members of the different Orders, or between the different species referable to the same Order, or even to the same genus—the effects of season must be taken account of, as constituting one important element among the many influences involved in bringing about the final result.

The Flora of the Plots; Orders, Genera, and Species represented.

Under this heading we propose to consider the number and the general character of the plants which have been observed during the course of the experiments on all the plots collectively.

Number of Orders, Genera, and Species.—The total number of species observed upon the plots is 89, comprised in 63 genera, and 22 Orders. The Dicotyledons number 59 species; the Monocotyledons 26; and the Acotyledons (including three Mosses but excluding Fungi) 4. The following is a list of the Orders, and of the number of genera and species within each, represented on the plots. As will be seen, the sequence of the Orders is according to the number of species they respectively contributed to the herbage of the plots (see Table XXXV., p. 1207).

TABLE XXXV.

Orders.	Number of genera.	Number of species.
1. Graminæ	14	20
2. Compositæ	12	13
3. Leguminosæ	5	10
4. Rosaceæ	5	6
5. Ranunculaceæ	1	5
6. Umbelliferæ	5	5
7. Labiatæ	3	3
8. Polygonaceæ	1	3
9. Liliaceæ	3	3
10. Caryophylleæ	2	3
11. Scrophulariaceæ	1	3
12. Musci	1	3
13. Rubiaceæ	1	2
14. Plantaginaceæ	1	2
15. Cruciferæ	1	1
16. Hypericaceæ	1	1
17. Dipsaceæ	1	1
18. Primulaceæ	1	1
19. Orchidaceæ	1	1
20. Juncaceæ	1	1
21. Cyperaceæ	1	1
22. Filices	1	1
Total	63	89

The number of species detailed in the foregoing table does not, however, give any idea of the degree of predominance or of the absolute quantities of any particular species, or of the number of species, on any individual plot. It may happen that one species, *e.g.*, *Dactylis glomerata*, may, in one season, or under one particular manurial condition, all but monopolise the area of the plots. An estimate of the relative preponderance of the different species is only arrived at by observation during growth, and after the removal of the crop, and by the careful analysis of the samples from the results of which the percentage and the weight of each species is deduced, as explained in the introduction.*

* In reference to this subject the following statements relating to the absolute number of individual plants in a given area may be cited.

DARWIN, 'Origin of Species,' chapter 3, mentions 357 seedlings of various kinds as having come up upon an area 3 feet long and 2 feet wide, previously cleared. Of these no less than 295 were destroyed chiefly by slugs or insects.

SINCLAIR, in his 'Hortus Gramineus Woburnensis' (1824), p. 244, 8th edition, gives a table showing the number of distinct rooted plants of various species found in one square foot in nine separate localities. The number varied from 1,798 to 634; and where particular species only were grown by themselves, as in the case of rye grass, to 75 only. Of the 1,798 plants in one foot square of a well managed water meadow, 1,702 were grasses, and 96 clover and other plants. Of 910 plants in a foot square of old pas-

It is desirable in this place to give a complete list of the species observed, together with a statement of the number of plots on which their presence was ascertained, in whatever amount, large or small, in each of the four separation years. In some cases a particular species may be very largely represented on a given plot, while on another, although it may have been observed on the ground during the course of the season, it may have disappeared prior to the samples being taken, or it may have been present in such small proportion as not to come in appreciable quantity into the samples taken at one particular time. This remark applies especially to those Leguminosæ and miscellaneous plants whose presence on particular plots is all but infinitesimal. Although it has been thought desirable to enumerate all the species which have, at any time, been noticed on the plots, yet it is to be observed that the total number of species occurring in such quantity as to be represented in the samples, even from plots where the vegetation is the most varied, does not exceed an average of 50.

In the complete list which here follows, Table XXXVI., the species are arranged in the three groups of *Grasses, Leguminosæ,* and *Miscellaneous Plants.*

ture in Woburn Park, 880 were grasses, 30 clover and other plants, the number of separate species being only 12.

Drs. Oemler and Fuchs (Die Landwirth. Versuchs-Stat., Bd. xvii, 211) give the following table showing the number of plants growing in one square foot of meadow-land in Schleswig :—

	No. of Plants.
Festuca pratensis	100
Holcus lanatus	66
Poa pratensis	64
Phleum pratense	59
Avena elatior	41
Dactylis glomerata	32
Lolium perenne, fine	24
Lolium perenne	22
Alopecurus pratensis	14
Rumex Acetosa	4
Ranunculus repens	3
Poa annua	2
Per square foot	431

These figures suffice to show the great range of variation as to the number of individual plants found under different circumstances according to the intensity of the struggle and competition between them on a given area; and they bring out the fact that the number is less in proportion as the number of species is less. That is to say, complexity of herbage is an indication of feeble competition, and hence the greater number of individual plants; whilst a small number of species is most probably associated with more active struggle, greater luxuriance of individual plants, and therefore a smaller number in a given area.

Darwin, in his 'Origin of Species,' chapter 3, alludes to the same fact in these words: "The struggle almost invariably will be most severe between the individuals of the same species, for they frequent the same districts, require the same food and are exposed to the same dangers."

TABLE XXXVI.—Complete List of Species that have been either found in the samples, or observed on the plots.

	Number of Plots on which found in:—				Mean.
	1862. (1)	1867. (1)	1872. (1)	1877. (1)	
GRAMINEÆ.					
1. Anthoxanthum odoratum, *L.*	19	20	22	22	21
2. Alopecurus pratensis, *L.*	19	20	22	22	21
3. Phleum pratense, *L.*	6	5	6	3	5
4. Agrostis vulgaris, *With.*	19	20	22	22	21
5. Aira cæspitosa, *L.*	5	3	17	9	9
6. Holcus lanatus, *L.*	19	20	22	22	21
7. Avena elatior, *L.*	18	20 (2)	20	21 (3)	20
8. „ pubescens, *L.*	20 (4)	20	20	20	20
9. „ flavescens, *L.*	19	20	22	22	21
10. Poa pratensis, *L.*	19	20	22	22	21
11. „ trivialis, *L.*	19	20	22	22	21
12. Briza media, *L.*	18 (5)	15 (6)	17	12	16
13. Dactylis glomerata, *L.*	19	20	22	22	21
14. Cynosurus cristatus, *L.*	19 (7)	14	16	16 (8)	16
15. Festuca ovina, *L.*	19	20	22	22	21
16. „ pratensis, *Huds.*	17	16	18	16	17
17. „ elatior, *L.*	0	0	0	1	1
18. „ loliacea, *Huds.*, a var. of pratensis	0	0	0	2	1
19. Bromus mollis, *L.*	19	18	19	12	17
20. Lolium perenne, *L.*	19	20	21	21	21
LEGUMINOSÆ.					
1. Trifolium repens, *L.*	17	17	18	16 (9)	17
2. „ pratense, *L.*	17 (10)	14	17	18 (11)	17
3. „ minus, *Sm.*	0	0	0	1	1
4. „ procumbens, *L.*	1	1	1	0	1
5. Lotus corniculatus, *L.*	16 (12)	14	15	20 (13)	16
6. „ major, *Scop.*	0	0	0	1	1
7. Lathyrus pratensis	17	19 (14)	19	2 (15)	19
8. Ononis arvensis, *L.*	1 (16)	1 (17)	1	1	1
9. Vicia sepium, *L.*	0	0	1 (18)	0	1
10. „ cracca, *L.*	0	1 (19)	1 (20)	1	1

(1) Total number of plots in 1862, 19; in 1867, 20; and in 1872 and 1877, 22.
(2) In quantity sufficient to be represented in the samples from 18 plots only, though observed on 4 others during growth.
(3) In 19 samples only. (4) In 19 samples only. (5) In 9 samples only. (6) In 9 samples only. (7) In 14 samples only. (8) In 14 samples only. (9) In 15 samples only. (10) In 15 samples only. (11) In 15 samples only. (12) In 10 samples only. (13) In 15 samples only. (14) In 15 samples only. (15) In 15 samples only. (16) In no sample. (17) In no sample. (18) In no sample. (19) In no sample. (20) In no sample.

TABLE XXXVI. (continued).—Complete List of Species that have been either found in the samples, or observed on the plots.

	Number of Plots on which found in:—				Mean.
	1862. (1)	1867. (1)	1872. (1)	1877. (1)	
MISCELLANEOUS SPECIES.					
Ranunculaceæ—					
1. Ranunculus acris, *L.*	19 (2)	17 (3)	16	21 (4)	18
2. ,, bulbosus, *L.*	19	17	18	19 (5)	18
3. ,, repens, *L.*					
4. ,, auricomus, *L.*	0	1 (6)	1 (7)	1	1
5. ,, Ficaria (8)	0	0	0	0	0
Cruciferæ—					
6. Cardamine pratensis, *L.*	0	0	2 (9)	0	1
Caryophyllæ—					
7. Stellaria graminea, *L.*	16 (10)	13	14	15 (11)	15
8. ,, Holostea, *L.*	0	0	0	1	1
9. Cerastium triviale, *Linn.*	15	15	16	16 (12)	16
Hypericineæ—					
10. Hypericum perforatum, *L.*	0	1	0	1	1
Rosaceæ—					
11. Potentilla reptans, *L.*	6	6	9	16 (13)	9
12. ,, Fragariastrum, *Ehr.*	0	1	1	1	1
13. Alchemilla vulgaris, *L.*	0	0	0	1 (14)	1
14. Agrimonia Eupatoria, *L.*	2	4	5	6 (15)	4
15. Poterium Sanguisorba, *L.*	1	2	2	2	2
16. Spiræa Ulmaria, *L.*	1	2	3	6	3
Umbelliferæ—					
17. Conopodium denudatum, *Koch*	19	20	22	22	21
18. Pimpinella Saxifraga, *L.*	18	17	20	20 (16)	19
19. Heracleum Sphondylium, *L.*	15 (17)	3 (18)	10	14	11
20. Anthriscus sylvestris, *Hoffm.*	2 (19)	3	4	3 (20)	3
21. Daucus Carota, *L.*	0	0	1 (21)	0	1
Rubiaceæ—					
22. Galium verum, *L.*	14 (22)	14 (23)	15	19 (24)	16
23. ,, Aparine, *L.*	1	0	2	7	3
Dipsaceæ—					
24. Scabiosa arvensis, *L.*	7	6 (25)	10	11	9
Compositæ—					
25. Centaurea nigra, *L.*	15 (26)	17 (27)	18	17	17
26. Carduus arvensis, *Curtis*	2 (28)	2	1	2 (29)	2
27. Bellis perennis, *L.*	5 (30)	5	6	8 (31)	6
28. Achillea Millefolium, *L.*	19	20	20	21	20
29. Chrysanthemum Leucanthemum, *L.*	1 (32)	4 (33)	1	4 (34)	3
30. Senecio erucifolius, *L.*	0	0	1 (35)	0	1
31. Hypochæris radicata, *L.*	0	5 (36)	1 (37)	0	2

(1) Total number of plots in 1862, 19; in 1867, 20; and in 1872 and 1877, 22.
(2) In quantity sufficient to be represented in the samples from 10 plots only.
(3) In 14 samples only.
(4) In 15 samples only.
(5) In 16 samples only.
(6) In no sample.
(7) In no sample.
(8) In no sample, but observed on 11 plots in 1871.
(9) In no sample.
(10) In 8 samples only.
(11) In 13 samples only.
(12) In 15 samples only.
(13) In 10 samples only.
(14) In no sample.
(15) In 4 samples only.
(16) In 19 samples only.
(17) In 1 sample only.
(18) In 2 samples only.
(19) In no sample.
(20) In 2 samples only.
(21) In no sample.
(22) In 2 samples only.
(23) In no sample.
(24) In 13 samples only.
(25) In 5 samples only.
(26) In 8 samples only.
(27) In 5 samples only.
(28) In 13 samples only.
(29) In 5 samples only.
(30) In 5 samples only.
(31) In 13 samples only.
(32) In 1 sample only.
(33) In 12 samples only.
(34) In 15 samples only.
(35) In 1 sample only.
(36) In 1 sample only.
(37) In 1 sample only.
(38) In 1 sample only.
(39) In 2 samples only.
(40) In no sample.
(41) In 2 samples only.
(42) In 5 samples only.
(43) In 1 sample only.
(44) In 2 samples only.
(45) In no sample.
(46) In no sample.
(47) In no sample.

TABLE XXXVI (continued).—Complete List of Species that have been either found in the samples, or observed on the plots.

	Number of Plots on which found in :—				Mean.
	1862. (1)	1867. (2)	1872. (3)	1877. (4)	
MISCELLANEOUS SPECIES (continued).					
Compositæ (continued)—					
32. Tragopogon pratensis, *L.*	4	5	6	7 (5)	5
33. Leontodon hispidus, *L.*	5	8	6	6	6
34. „ autumnalis, *L.*	1	3	1	1	2
35. Taraxacum officinale, *Wigg.*	17	17 (6)	13	10	14
36. Sonchus oleraceus, *L.*	0	0	1 (6)	0	1
37. Hieracium Pilosella, *L.*	3	4	3	4 (5)	4
Plantagineæ—					
38. Plantago lanceolata, *L.*	16	14	14	16	15
39. „ media, *L.*	0	1 (6)	0	0	1
Scrophularineæ—					
40. Veronica Chamædrys, *L.*	14	15	16	16 (7)	15
41. „ serpyllifolia, *L.*	0	1 (8)	2 (8)	2	1
42. „ officinalis, *L.*	0	0	0	1 (9)	1
Labiatæ—					
43. Thymus Serpyllum, *L.*	0	0	0	2	1
44. Prunella vulgaris, *L.*	3	6	6	12 (10)	7
45. Ajuga reptans, *L.*	3	5	7	11 (11)	7
Primulaceæ—					
46. Primula veris, *L.*	6 (12)	6 (13)	1	8 (14)	5
Polygonaceæ—					
47. Rumex Acetosa, *L.*	19	20	22	22	21
48. „ crispus, *L.*	0	2 (15)	2 (16)	2 (17)	2
49. „ obtusifolius, *L.*	0	1 (18)	1 (19)	1 (20)	1
Orchideæ—					
50. Orchis Morio, *L.*	3 (21)	0	1 (22)	1 (23)	1
Liliaceæ—					
51. Scilla nutans, *Sm.*	1	0	3	6	3
52. Fritillaria Meleagris, *L.*	0	2 (24)	1 (24)	0	1
53. Ornithogalum umbellatum, *L.*	0	0	1	0	1
Juncaceæ—					
54. Luzula campestris, *Willd.*	16	20	19	19 (25)	19
Cyperaceæ—					
55. Carex præcox, *Jacq.*	12	13	16	10	13
Filices—					
56. Ophioglossum vulgatum, *L.*	4	4 (27)	4 (27)	3 (28)	4
Musci—					
57. Hypnum squarrosum, *L.*	} 10	8	15	20	13
58. „ rutabulum, *L.*					
59. „ hians, *Hedwig. f.*					

(1) Total number of plots in 1862, 19; in 1867, 20; and in 1872 and 1877, 22.
(2) In quantity sufficient to be represented in the samples from 6 plots only.
(3) In 16 samples only.
(4) In no sample.
(5) In 3 samples only.
(6) In no sample.
(7) In 13 samples only.
(8) In no sample.
(9) In no sample.
(10) In 7 samples only.
(11) In 10 samples only.
(12) In 4 samples only.
(13) In 2 samples only.
(14) In 6 samples only.
(15) In no sample.
(16) In no sample.
(17) In 1 sample only.
(18) In no sample.
(19) In no sample.
(20) In no sample.
(21) In no sample.
(22) In no sample.
(23) In no sample.
(24) In no sample.
(25) In no sample.
(26) In no sample.
(27) In no sample.
(28) In 18 samples only.
(29) In no sample.
(30) In 1 sample only.

In addition to the foregoing, it may be mentioned that seedlings of the common oak, *Quercus Robur L.*, occasionally come up in small numbers near the trees, but they are never able to maintain themselves, and may be passed over without further notice.

The nomenclature of the species which has been adopted is that of Sir J. Hooker's 'Student's Flora.'

The classification into gramineous, leguminous, and miscellaneous plants has many practical advantages for our special purpose. Grasses constitute by far the largest proportion of the plants found on the plots; Leguminosæ are very distinct in many aspects, and, as is more fully shown in the sections treating of the effects of the various manures, they often manifest contrary tendencies to those of the grasses—a circumstance not to be wondered at when it is remembered how great is the difference between the leaves and the roots of most grasses and those of Leguminosæ, and coincidently how different are the requirements of the two.

The relation of the various miscellaneous orders to the grasses, and to the leguminous plants, and to one another, cannot be dealt with in a few generalising paragraphs. The mode of growth, and the root-development, of most of them are, speaking generally, much more like those of the leguminous plants than those of the grasses. That their greater or less relative prevalence is very much an affair of season, encouraging or discouraging, as the case may be, the growth of their competitors, the grasses, is shown in the subsequent sections relating to the several plants and plots. Again, though present conditions avail much in regulating the distribution and comparative prevalence of various groups of plants, it is now well recognised that causes anterior to the existing order of things have determined the existence of larger or smaller number of the species of each particular family.

The alleged antagonisms between plants.—Dureau de Lamalle* was one of the first to call attention to the apparent antagonism of certain plants, and to their alternate predominance, the one over the other—a fact frequently observed in the case of forests. He pointed out that grasses were in his experience the most powerful enemies of Saintfoin and of Lucerne; that they overcome them when growing together, without however being able to destroy them utterly. Moreover, he remarked that in some isolated plateaux never manured or irrigated, he saw, five or six times in the course of 30 years, grasses and Leguminosæ lose and regain the prominence one over the other. Similar phenomena have been observed at Rothamsted, as will be illustrated in the sequel.

When, however, as at Rothamsted, investigation is pushed further, and when particular species of grasses, or of Leguminosæ, &c., are examined as to their behaviour

* "Mémoire sur l'alternance, ou sur ce problème: la succession alternative dans la reproduction des espèces végétales, vivantes en société, est elle une loi générale de la nature?"—Ann. Sc. Nat., Ser. 1, 1825, vol. 5, p. 50. See also Alphonse de Candolle, 'Géographie Botanique,' tom. i., p. 472.

with particular manures, then it is found that just as certain orders, taken collectively, say grasses, and Leguminosæ, have opposite tendencies and different requirements, so certain species of the same Order and even of the same genus may exhibit contrary phenomena. Just as Leguminosæ as a whole may be practically banished, and Gramineæ made to prevail, so certain species of Gramineæ or of Leguminosæ can be driven out, or, at least, some particular species may be so greatly favoured that the others are banished, either by the superior vigour exhibited by the victorious species, or by the directly injurious agency of the manure applied. From this point of view the comparative details hereafter given as to various members of the same genus which exhibit opposite tendencies, especially *Poa pratensis* and *Poa trivialis*, and the different species of *Avena*, which nevertheless manifest very opposite tendencies, may profitably be studied.

This opposite tendency between nearly allied plants (further illustrated by the occasional impossibility of grafting, or of mutually fertilising, allied species), is a most interesting phenomenon, and of great importance from both a scientific and a practical point of view. Several illustrations of it will appear further on; meanwhile we may, in passing, allude to the necessity for caution in the interpretation of isolated experiments which this fact demonstrates. Because a particular grass, or other plant, is little benefited by ammonia-salts, for instance, it does not follow that it will not be favoured by nitrates; nor, because if while growing in association with other species it may not be specially benefited by a particular manure, does it follow that it would not derive advantage from the same substance when growing separately.

The alleged antagonism of certain plants has been supposed to be due to the injurious effects of root-excretions;* but this supposition is, to say the least, not a sufficient explanation of the observed phenomena. The true explanation of the facts recorded lies probably in the varying conformation and requirements of different plants, as will be illustrated in subsequent sections. The advantages derived from the practice of rotation also receive illustration from these same circumstances.

Habit and Conformation of Plants: Organisation by means of which they maintain or improve their position, or succumb in competition with others.

Before passing to the consideration of individual species, a few general remarks on the structure and mode of life of the plants with which we have to deal are requisite. All the plants are, indeed, well known, and many of the facts we have to call attention to are equally familiar. Nevertheless, it is important to note the points of greatest significance in the consideration of the endowments by virtue of which plants growing in association maintain their position, prevail over, or succumb to their competitors.

* See A. P. De Candolle, 'Physiologie Végétale,' p. 1474; Duchartre's 'Eléments de Botanique,' p. 246; Braconnot, 'Ann. Phys. et Chimie,' 1839, t. 72, p. 27.

Almost all the plants on the plots are perennials—very few are annual. The duration of the plant in some cases is indeed increased by the rarity with which seeds are perfected. The hay-crop being cut when but few plants have had time to ripen seed, and some have not even been able to flower, it is clear that the annual plants have little chance of maintaining their ground. In other cases, however, seeds are produced abundantly.

Hardiness, &c.—The hardiness or power of resisting frost or drought, especially during the growing season, is a matter evidently of foremost consequence. Although most of the plants can bear a very low temperature with comparative impunity, if in a quiescent state, yet the young growing shoots or leaves are liable to suffer injury from frost. Some of the plants on the plots are protected from the action of frost by the remains of the dead leaves of the former year; but while this protection may be useful in winter, it may be disadvantageous in spring by promoting premature growth. The early or late development in spring then becomes an element of considerable importance among the causes tending to the supremacy of certain plants over others. Supposing two plants to have started into growth together, it is obvious that the more hardy of the two would have a better chance of enduring the onslaught of frost at this critical period than the more tender one, and would hence gain the advantage over it.

Apart from the varying effect of frost or other injurious circumstance on different plants, it has to be taken into consideration that different plants have different seasons of growth. All other conditions being equal, some species, or individuals by hereditary tendency, start into growth earlier or later than others. It is clear that the late-growing species would be at a disadvantage when growing in association with more early developed plants of equal hardihood; because the latter would have occupied the ground, to some extent, before the former had had time to develop themselves.

So far as ability to withstand drought is concerned, it is certain that it depends most materially on the underground development, either of the stock or of the roots proper. A striking illustration of this has been given at p. 334, *et seq.*, of Part I. In considering the competition that is going on between one description of plant and another, the form, size, and direction of the leaves, the manner in which they are protected from the effects of excessive radiation, and their tendency to transpire much or little, according to the surface they expose to the air, &c., have also to be taken into account, as well as the variation in their anatomical organisation according to the circumstances under which they grow. These points are referred to in more or less detail under the head of the individual species; but some general remarks may appropriately be given in this place.

Roots and root-hairs.—It is necessary to draw particular attention to the generally recognised difference between the true feeding roots and those organs also commonly called roots, but whose office is that of transmitting or storing nutrient matter or

substances capable of conversion into such. The true feeding roots, those portions which absorb the watery solutions from the soil, are, as is well known, the minute fibrils, and even of these it is the portions near to the distal ends only which are active. From the sides of these fibrils often protrude the delicate root-hairs which have the same powers of absorbing watery solutions from the soil that the fibrils themselves have. These root-hairs vary greatly in number even in the same plant, and they differ in dimensions in different individuals, some plants being wholly destitute of them. Their number depends upon the nature of the medium in which they are placed.* Where the soil is porous and charged with moisture the root-hairs are abundant, so much so that they give a white cobwebby appearance to the roots in such situations. Their relation to the temperature of the soil has not been properly worked out, although it is clear that a relatively warm soil is favourable to their development. They are developed on all sides from above downwards.

The production of root-hairs appears to be influenced by much the same circumstances as that of the root-fibrils themselves. Moreover, the root-hairs are often specially abundant in the case of seedling plants, containing little or no reserve of water, and at the point where growth is going on actively, and a large demand for water and nutriment consequently exists. The duration of these minute hairs is often very short. Once the necessity for their presence is passed, or the conditions for absorption become unfavourable, they shrivel and die.

So far then as absorption of nutritive matter is concerned, it is the minutest fibrils with their hair like out-growths that we have to consider. We know, in a general way, that their number is much greater in the same species of plant under some circumstances than under others. If they are growing in very fertile, moist, well aërated and well drained soil, the production of feeding roots (and of root-hairs in the case of the plants producing them), is greater than under opposite circumstances. Under such favourable conditions they are short and densely matted, whereas in sterile soil they are elongated and produce but few fibrils. The dense leash of feeding roots made by trees whose roots have access to water is well known; as also the network of root-hairs formed around any food-yielding substance, such as a piece of leather or bone.

Nobbe and Sachs have shown as a result of well devised experiments, that where the fertilizing material was thoroughly mixed with the soil, the root-fibrils were most abundant, and relatively few in the intervening less rich portions. The experiments were varied in method, but in all cases the results showed that the "principal development of the roots occurred in the immediate vicinity of the material which could furnish

* "Notes on Root-hairs and Root-Growth," by M. T. Masters, Journal of Royal Horticultural Society, vol. v. (1879), p. 173. [A paper of M. Mer, "De la constitution et des fonctions des poils radicaux," read before the French Association for the Advancement of Science at Reims in 1880, but of which we have only seen a very brief abstract, should be consulted.—Note added, October, 1882.]

them the nutriment."* HELLRIEGEL† found that a plant of barley, in rich porous soil had made roots of the aggregate length of 128 feet, while a similar specimen in coarser, heavier land had only 80 feet; and numerous measurements of a similar character have been made by NOBBE in the course of his water-culture experiments.

In a mixed pasture where a great variety of species is growing, there is a great diversity in the natural habit of the plants, irrespective of the direct effect of soil or manure. Some roots go much deeper than others; some branch more than others, and in this way different plants, as it were, tap different layers of soil, and so utilize portions that would be left unused by others. As a general rule, if the root-range of any given plant be restricted, the appropriate food may be presumed to be near at hand, and in sufficient quantities. If, on the contrary, the root-range is wide, then the food is distributed over a wider area.‡

There is evidence to show that roots by virtue of the acid fluid with which the membrane of the root-hairs or of the absorbent cells is saturated have, at least in some cases, the power of dissolving, and it may be presumed directly absorbing, substances with which they come in contact;§ but this point has not been made a subject of investigation at Rothamsted.

It stands to reason that a large production of root-fibrils and root-hairs would exhaust the soil in their immediate neighbourhood sooner, and more thoroughly, than a more limited development would do. But it must be remembered that long, deeply-rooting plants, or plants with thick root-branches, penetrating downwards to a considerable depth, may, in the aggregate, produce quite as many or more feeding roots, though they may be more widely diffused and not so apparent to the eye. These differences are, in a general sense, denoted by the ordinary terms of surface-rooting or deep-rooting plants. The surface-rooting plants have usually finely branched root-fibres in great numbers, not penetrating very deeply, and liable to be injured by drought or frost. The more deeply-rooting species are usually of longer duration, with coarser, stronger, less branched, but much more deeply-penetrating roots. Such plants, therefore, are better able to withstand drought; first, because they are not so much affected by surface supply, and next, because they can obtain moisture from a greater depth and can accumulate a larger store of it in their tissues. These differences were well illustrated in 1870, a year very remarkable for the drought which prevailed. In that year, as has been more fully explained in Part I. (p. 334, *et seq.*), samples of the surface soil and turf, and of the subsoil of some of the experimental plots were taken, and the distribution of the roots was examined at various depths down to 54 inches. The plots selected

* SACHS, 'Physiologie Végétale,' ed. MICHELI, p. 196.

† HELLRIEGEL, HOFFMANN'S Jahresbericht, 1864, p. 106.

‡ DUREAU DE LAMALLE, *op. cit.*

§ DIETRICH, in HOFFMANN'S Jahresbericht, vi., 3; SACHS, 'Physiologie Végétale,' ed. MICHELI, p. 208. See also VAN TIEGHEM, 'Traité de Botanique,' p. 256 [1882], where the action of the root on the soil is compared to a process of digestion, a process carried on only in the part of the root covered with root-hairs as a result of the contact of their membrane charged with "sucs" and the particles of soil.

were one of the two unmanured ones, Plot 9 (mixed mineral manure and ammonia-salts), and Plot 14 (mixed mineral manure and nitrate of soda).

In connexion with this subject it must be borne in mind that in many perennial plants, while the main body and principal branches of the root persist from year to year, the fibrils and root-hairs, as before mentioned, die off, and are renewed only when circumstances are favourable. The relatively early or late period at which root-growth of this character takes place would naturally affect the vigour of the plant and influence it for good or ill in its competition with others.*

Root-stock, rhizome, &c.—Under this head we may include, for our present purpose, those portions of the root not directly concerned with the absorption of moisture or of food from without; those which are more or less woody or succulent, and which serve as holdfasts, as conduits, or as depositories for water and nutritive matters. More often than not these organs, in a strict botanical sense, are underground stems, having the internal structure and mode of growth of stems or of branches, and not of roots proper. It is not necessary to go into detail on these points here; suffice it to say that, as a general rule, any portion of the plant, subterranean or not, which bears leaves or scales (which are the rudiments of leaves) or buds, is to be considered as a stem or branch, and not as a root.

Speaking broadly, the object of these structures is to fix the plant in the soil, to enable it to avail itself of the food in the deeper layers of the soil, by emitting feeding roots when the conditions are favourable, and at greater depths than is, as a rule, possible in the case of fibrous roots, to store up water and nutritive matters, to force their way by progressive growth at their tips into fresh and unoccupied territory, or to make their way into that occupied by their neighbours if these be too weak, either intrinsically or from force of circumstances, to resist the intrusion. Often the subterranean stem or branches serve the purpose of propagation or of reproduction. Often, too, they serve, to some extent, as organs of locomotion; for instance, the stock continues to grow at one end, year after year, the opposite end gradually dying away. In the course of a few years the plant, therefore, occupies quite a different position from that which it had at first.

The details of these differences in form and structure are given in the ordinary text-books of botany, though little is therein said upon them from our present point of view. For our purposes we may speak of these "stocks" and "root-stocks" as: 1. Elongated and more or less branched, either descending vertically or spreading, for

* On the general question of root-growth and root absorption the most important paper known to us is that of Sachs in the "Land. Versuch. Stat.," 1859, iv., 1, wherein the researches of other experimenters are summarised. See also Michelt's French translation of Sachs' 'Physiologie Végétale,' p. 187. The more recent papers of the same author, "Ueber das Wachsthum der Haupt und Nebenwurzel" (Arbeiten des Bot. Institut in Wurzburg, 1873, 1874) should also be consulted. [A paper of M. Mer "Des modifications de structure et de forme qu'éprouvent les racines suivant les milieux ou ils végètent," read before the French Association for the Advancement of Science at Rheims in 1880, is only known to us by the brief abstract in the Bulletin of the Botanical Society of France, 1881, Rev. Bibl., p. 213.—Note added, October, 1882.]

a relatively short distance, at a greater or less angle on, or slightly beneath, the surface of the soil; 2. As dilated and tuberous; 3. As contracted and tufted, as in many of the grasses, whose tufts or "hummocks" consist of the short contracted stocks emitting plentiful root-fibres below, and dense tufts of leaves above; 4. As creeping; as in the case of Twitch or Bent (*Triticum repens*), where the stock gives off slender creeping branches on or beneath the surface, such branches sometimes having the power of rooting freely at the nodes, as in Twitch; at others not rooting freely, as in the "stolons," or offshoots of *Achillea Millefolium*.* In any case they are usually terminated by a bud or cluster of leaves, surrounding a "growing point," and which is capable of rooting and forming a distinct plant.

Stem.—Under this head we may include all those organs whose office it is to bear well-developed leaves and flowers. It is not necessary to discuss the many forms the stem may assume. It will suffice to recall that some plants have but a single stem springing from the root-stock, while, in other cases, as in many grasses, the stems or culms are numerous and tufted. Of course, if the root-stock branches there will be stems corresponding to those branches. The number of the stems and of their branches, their habit, their direction, whether erect or decumbent, their texture—all have an important influence on the terms of competition between different plants. The production of numerous stems, as in those grasses which "tiller," seems connected with the necessity for securing sufficient nutriment from the air, solar light, &c., in a short space of time.

Leaves.—On ordinary meadow land a great variety in the shape, size, and direction of leaves, as well as in the mode in which they are packed in the bud, may at once be seen. There are the grasses with their long, thin, narrow, folded or convolute leaves, at first more or less erect, afterwards, according to their position on the stem or culm, spreading. There are the Plantains and Clovers, with their broad, flat leaves; there is the Daisy, with its spoon-shaped leaves pressed flat to the soil; and between these extremes every conceivable variation in size, shape, and direction occurs. These variations are, it is to be supposed, sometimes associated with corresponding differences in internal structure, and more especially with diverse functional endowments, as a result of which the life-history of the plants presents the differences which are so obvious, but the explanation of which is at present so incomplete.

The influence that the mere shape and direction of leaves may have upon the struggle between different plants is strikingly illustrated in early spring, before they have started into growth. At that time, many of the "weeds" of grass-land have the form of flat rosettes, resting immediately on the surface of which they occupy circular patches of considerable area. Such is the case in the Plantain, in the Dandelion, in the Hawkweed, in the Daisy, and many others. Now, if these plants start into

* A note of Mr. DARWIN's may be quoted here as showing the beneficial effects of cross fertilisation on *Origanum vulgare*:—"The superiority of the crossed plants was truly wonderful, owing to their increase by stolons."—('Fertilisation of Flowers,' p. 96.)

growth earlier than the neighbouring grasses they will necessarily have an advantage over them, and will more or less crowd them out. If on the contrary the grasses begin to grow first, or the growth of the broad-appressed leaved plants be checked, then the grasses, or other plants, will get the start and overpower the rest.* In other cases, the flat leaves closely pressed against the soil prevent the growth of other plants; for instance, on an ill-kept lawn, the Daisies increase partly by virtue of their much divided stock, partly by their flat leaves closely pressed to the soil, and preventing the growth of other plants. In the Buttercups the leaves, which in early spring form a rosette appressed to the ground, become speedily lifted from it by the elongating leaf-stalks, and room is thereby left for the encroachments of the grasses or other plants which may be in the neighbourhood. In plants like *Conopodium denudatum*, the leaf in its initial stage is packed into very small compass, almost like a furled flag. In this state it is thrust up amid other leaves till it gets space to unfold. In other cases, as in the clovers, the two halves of the young leaves are folded like a sheet of note-paper and remain so till by the lengthening of the stalks they grow beyond the obstruction. In the *Festuca ovina* the thin, slender, cylindrical leaves easily make their way amongst the surrounding foliage, and this may be one reason for the predominance of the plant, while its comparatively small evaporating surface may also stand it in good stead. In fine, there are endless adaptations such as those cited, well known to the botanist, and familiar to the most superficial observer of plants. It is not needful to dwell upon them here at any greater length, our object being not to call attention to special arrangements, but to the general fact that all these variations, in the growth and "habit" of plants, are elements to be considered in studying the nature and the force of the struggle for existence among them, and the circumstances that determine the "survival of the fittest."

With reference to the minute anatomical structure of the leaves and herbaceous parts of plants, it is well known that external conditions have no inconsiderable influence upon them. The structure of aquatic plants is a case in point; the anatomical construction being profoundly modified as a consequence of the medium in which the plants grow. So, also, the increased succulence—due to augmented size or number of cells—seen in plants grown by the sea-side is matter of common observation. The densely woody contracted habit of shrubby plants growing on the higher mountains has also often been noted. Amongst the most recent investigations on this subject are those of M. DUVAL JOUVE, who has examined the structure of the leaves of grasses as modified

* In the spring of 1875 one of us was a witness of a struggle of this kind between *Cerastium triviale* and *Plantago lanceolata*. The frosts of March had very severely injured the outermost leaves of the Plantain, a large number of which were growing on an exposed railway bank where little else grew. Each plant was surrounded by a growth of *Cerastium triviale* which was much less damaged, if at all, by the frost, and which consequently invaded and, to a considerable extent, overpowered the Plantain. As the spring went on, however, the new leaves of the Plantain, when starting into growth, assumed an upward direction instead of the usual horizontal one, and the plant quickly outgrew the *Cerastium*, and so regained its supremacy.

by external conditions. Referring the reader to his paper* for full details, it may here be stated on his authority, that the hard woody fibres beneath the epidermis of the leaves of grasses—"the hypodermic fibres"—which form a protecting sheath to the fibrovascular bundles of which they are indeed a dependence, and which must greatly contribute to the rigidity of the leaf, are fostered in their growth in hot dry situations. Shade and moisture, on the contrary, are not favourable to their development. It is easy to see the bearing of these facts on the question of the struggle for existence. Speaking of the cellular or parenchymatous structure of the leaves of grasses the same botanist remarks that there are, speaking generally, three categories of cells: 1, those with green chlorophyll; 2, colorless cells without chlorophyll; 3, stelliform cells. The green cells predominate in grasses growing in cool shady localities; the colorless cells are relatively abundant in species growing on sandy sea-coasts; while the stelliform cells are especially abundant in aquatic species.

Flowers, &c.—It forms no part of our purpose to describe in detail the inflorescence or the floral structure of such well known plants as those which constitute the mixed herbage of the plots. A few general observations may, however, appropriately be made in illustration of the competition that is going on between them. Some of the plants on the plots never get an opportunity of flowering; others flower, but do not perfect their seed before they are cut by the scythe. It might be expected that the duration of such plants would be prolonged, as the flowering, and still more the seeding, is so exhausting to the plant. Some plants which do not get an opportunity of flowering or seeding before the first crop is cut, do so before the aftermath is taken. The early or late flowering is, therefore, an element to be considered.

Other matters relating to fertilisation, such as the question whether particular flowers are self-fertilised or fecundated by wind-wafted pollen, or by pollen carried by insects, are amply deserving of study, with special reference to the advantage or injury resulting to some of the competing plants by such complex interactions.† For instance, if in any given season the particular insects adapted to fertilise any particular flower were from any cause absent, or present in diminished numbers, the number of seedlings of that plant would be proportionately diminished, and *vice versâ*.

Some plants, again, like *Rumex Acetosa*, seed more abundantly than others. This is a dicœcious, wind-fertilised flower, whose seeds are dispersed in abundance, and as

* 'Ann. Sc. Nat. (Botanique),' 1875, vol. i., p. 367. [See VESQUE in the same publication, vol. xiii., 1882, p. 24, and STAHL as quoted by VESQUE; also HACKEL's 'Monograph of European Fescues,' of which an abstract is given in TRIMEN's 'Journal of Botany,' September and October, 1882.]

† With reference to the "relation of organism to organism, the most important of all relations," see DARWIN, 'Origin of Species,' chapter 3, and as to the relative advantages to the species of self or of cross-fertilisation, see DARWIN 'On the Effects of Cross and Self-Fertilisation in the Vegetable Kingdom,' and on 'The Different Forms of Flowers on Plants on the same Species.' As to the fertilisation of grasses, see BIDARD, Comptes Rendus, 1869, p. 1486; SYME, in 'Journal of Botany,' 1871, p. 173, and in 'Journal of the Royal Horticultural Society,' 1872, vol. iii., p. 7; SPRUCE in same publication, 1872, vol. iii., p. 4; A. S. WILSON, 'Gardeners' Chronicle', March 14, 1874.

will be seen in the sections relating to the plots, germinate freely, especially availing themselves of bare patches, occasioned by frost or drought killing the herbage. Doubtless the seedlings of other plants would grow equally well on such places, and sometimes indeed they do so, but the greater number of seedling plants of the *Rumex* give it an advantage over others which are less prolific.

The early seeding tendency would necessarily give an advantage to the plants that possessed it, as others would be cut prior to the ripening of the seed. As the plants on the plots are almost all perennials, this is of the less consequence; nevertheless, it is an important element in estimating the results of the competition between species which must not be overlooked. Among those species which ripen their seed before, or about the time of cutting, and whose seeds are therefore liable to be dispersed, are—*Anthoxanthum odoratum, Bromus mollis, Alopecurus pratensis, Poa trivialis, Ranunculus bulbosus, Pimpinella Saxifraga* (in second crop), *Conopodium denudatum* (sometimes), *Trifolium pratense* (occasionally), *Rumex Acetosa, Luzula campestris*, &c. Of course, allowance must be made for season and for the influence of manures.

General Effects of Manures on Vegetation.—In the experiments under consideration, the effects of the various manures on the vegetation were ascertained by observation of the plants during growth, noting the characteristic tendencies of development, by the botanical separation or analysis of the mixed herbage, and by the weight and chemical composition of the produce. The various results have been or will be brought out in detail elsewhere. But it should be called to mind here that a general tendency of nitrogenous manures is to favour luxuriant and continuous growth as distinguished from arrest and consolidation of that already formed; whilst that of mineral manures is to favour consolidation rather than luxuriance. Or, to put it in another way, a characteristic effect of nitrogenous manures is to favour the extension of foliage and give it depth of colour, whereas that of the mineral manures is to tend to stem-formation and production of seed. In fact, a relative excess of nitrogenous supply favours the extended growth of the organs of vegetation, prolonging their development, it may be until the resources of the plant are exhausted or the season is past. On the other hand, a relative excess of mineral manures may bring on premature ripening. It is the proper adaptation of the two descriptions of supply to the current requirements of the plant and of the season that gives both full, properly proportioned, and well-matured growth. It is obvious, therefore, that when a number of plants of different habits, and different periods of flowering and seeding are growing in association as in the mixed herbage of grass land, the character of the manure must exert a very potent influence on the struggle.*

It may be stated, however, that neither in the experiments at Rothamsted whether on individual plants or on plants growing in association, nor in those made at Chiswick

* For the effects of manures on individual species grown separately, see "Reports of Experiments on the Influence of Various Manures on Different Species of Plants," Journal of the Royal Horticultural Society, new series, vol. iii., p. 19, and "Second Report," vol. iii., p. 124, 1870; also 'Rothamsted Reports of Experiments on Different Crops.'

with individual species growing separately, has there been absolute change in distinctive form by the use of various manures. Changes of degree are indeed sometimes very marked, as, for instance, in the tufts of *Dactylis glomerata*. Again, such changes as there are are chiefly in the organs of vegetation—roots, leaves, and stems, which show greater or less relative amount, precocity, permanence, and so on; whilst the changes in the parts of the flower are much less. It is probable that more attentive observation would reveal differences in the processes of fertilization and in the germinating power as in the maturation of the seed.

General Occurrence of Certain Species:—Hostile Competition or Peaceful Association.

Certain plants occur with such frequency, and under such widely differing conditions, that it would seem as if they were in a great measure indifferent to the character of the soil or to that of the manure. There are indeed certain plants which if not crowded out by their more powerful neighbours seem to thrive on almost any soil and under almost any condition of manuring. The great extension of *Festuca ovina* under the most varied conditions of manuring is a case in point. We see illustrations of the constancy of occurrence, or of the same power of adaptation to varying conditions of soil, &c., in the case of wild plants generally. It is easy to pick out certain plants peculiar to limestone, or sandy or clay soils, as the case may be, but these are relatively few when compared with the large numbers that seem indifferent to the nature of the soil.* Again, observations of this character tend to show that it is the physical nature of the soil, its capacity for holding water and its permeability to roots, that are, in most cases, of greater importance than its more strictly chemical composition. It may also be stated, that plants growing in association with others of different species do not necessarily grow where the conditions of soil and climate seem to be, or are really most favourable to them individually, but in those localities where they can best maintain themselves in the competition with others. In a word, they do best where they can best adapt themselves to the combination of surrounding circumstances.† Any peculiarity of organisation which will help them in their struggle is of course a decided advantage. Such peculiarities, although they cannot be induced, may be, and are, enhanced by the action of manures.

In the continual internecine strife between plants, it is not always the resources of the plant itself which enables it to maintain or extend its ground. Its success

* Masters, "On the Flowering Plants of Oxfordshire," Transactions of the Ashmolean Society, 1857. For a summary of our knowledge on this matter, see Alph. de Candolle, 'Géographie Botanique,' vol. i., p. 423; and the more recent researches of Contejean, Ann. Sc. Nat. Bot., ser. 5, t. xx., p. 266, and ser. 6, t. ii., p. 223. While there is great difference of opinion as to the relative influence of various soils on plants, all are agreed that, with certain obvious limitations, the majority of plants are "indifferent" to the chemical or physical nature of the soil.

† For some general remarks on the conditions of the struggle, see the chapter on the extinction of species in the late Sir Charles Lyell's 'Principles of Geology,' and that on the struggle for existence in Darwin's 'Origin of Species.'

depends, as pointed out by A. P. CANDOLLE,* in a great measure on the number of its foes or of its allies among the animals and plants inhabiting the same region. Thus, for example, a plant which loves the shade may multiply, if some tree with spreading boughs and dense foliage flourish in the neighbourhood. Another, which if unassisted would be overpowered by the rank growth of some hardy competitor, is secure because its leaves are unpalatable to cattle, whilst they annually crop down its antagonist, and rarely suffer it to ripen its seed.

The same author, in his 'Physiologie Végétale,' tom. iii., p. 1471, in alluding to the relative development of the root fibrils in different plants, points out that when in any given area there are several individual plants of different degrees of vigour, the roots of the stronger will deprive those of the weaker of their nourishment, and that this inequality of action will confer an advantage on the first comer.

Some experiments bearing directly on the struggle among plants have been made by Professor HOFFMANN, of Giessen,† who watched the changes among plants growing together, and endeavoured to ascertain what were the circumstances which contributed to the success of the victors. In a previous set of experiments it had been found that the particular plants under observation grew equally well in different kinds of soil, provided due care were taken to prevent the growth of intruding weeds. Having arrived at this result, the several plants were left to themselves, with a view of determining how they would comport themselves without assistance against the inroads of weeds. It resulted that the weeds completely gained the ascendancy. The species which held out longest was *Asperula cynanchica*. This plant, after having been grown in a bed for three years, and protected from weed invasion by the use of the hoe, was then left to take care of itself. It held out for some four years, but was ultimately elbowed out by the intruders.

Professor HOFFMANN then set himself to observe the results of the internecine struggle between the weeds themselves, thinking that the ultimate survivors would perhaps prove to have special affinities for the soil in which they grew. Thus left to themselves the beds became so densely covered that in a square foot 460 living plants, and the remnants of many others which had succumbed, were counted. Every year in July the beds were examined, and every year the number of species was found to have diminished, till at length only a few were left; and these not only persisted, but slowly gained ground from year to year, and ultimately remained in possession of the plot.

Of 107 species under observation, all, or nearly all, found the most essential requisites of their existence equally well in all the varieties of soil, so that, other conditions being equal, the nature of the soil was indifferent. The species which remained victors, all the others being ultimately dispossessed, were *Triticum repens, Poa pratensis, Potentilla reptans, Acer pseudo-platanus, Cornus sanguinea*, native plants;

* Cited by LYELL, 'Principles,' vol. ii., ed. 10 (1868), p. 435.

† See 'Botanische Zeitung' (Beilage), 1865, and 'Landwirthschaftliches Wochenblatt des Ackerbauministeriums in Wien,' 1870; see also 'Gardeners' Chronicle,' 1870, p. 664.

and *Aster salignus*, *A. parviflorus*, *Euphorbia virgata*, and *Prunus Padus*, derived from the garden.

It may, therefore, be inferred that the district in which these experiments were made would in process of time, if no obstacle were afforded, become covered with meadows and woods—meadows in the low-ground and woods in elevated places. Again, the experiments show that the survival of certain plants has not been materially influenced by the nature of the soil. Thus, *Triticum repens* was ultimately spread over all the plots, whether of sand or of loam or of lime; whether drained or undrained. So also with *Poa pratensis* and *Potentilla reptans*.

As to the action of shade, it was found that low-growing plants, especially if annuals, disappeared rapidly; while taller-growing ones, such as the *Triticum*, *Prunus Padus*, &c., survived. The general results at Rothamsted and at Chiswick are consistent with those established by Professor HOFFMANN, and combine to show that the survival of certain plants is due much less directly to external conditions than to the "habit" of the plant itself; that is, as already stated, to the facility the plant has of adapting itself to varying external conditions, and thus of triumphing over others less favourably endowed in this wise.

The immediate source of victory lies very generally in the powerful root-growth of the survivors; including under the general term root, not only the root proper, but the offshoots and runners which are given off just below or on the surface of the ground. Indeed, this habit of growth is more advantageous to plants in such a struggle than the development of the true root downwards would be.

With reference to these questions of struggle, competition, and association, it is requisite to distinguish clearly between those cases in which the competition or the struggle is direct, and those in which it is indirect. In some cases where plants grow in association the strong overpower the weak by virtue of their superior endowments, in others one plant gains the advantage because it was the first to take possession of the ground; or because, for some reason or another, no resistance is offered to its spread. But, while among individual plants of the same species, having the same requirements and growing in association, there must necessarily be hostile competition which would disturb the balance of vegetation, and result in the survival of the fittest and the destruction of the weakest, there is also an opposite process which tends to maintain an equilibrium. Different plants have different requirements, and if these be supplied at the same time and place, the vegetation may be of a very mixed character, and no one plant or set of plants gain preponderance over the rest, till some circumstance arises to disturb the equilibrium. We have then to discriminate between the effects of hostile competition and those of peaceful concomitance or association. DE CANDOLLE, in the paper previously cited, asserts that *all* plants within a given area are at war with one another; but this assertion, in view of what has just been stated, requires to be taken in a qualified sense.

We have already alluded to the fact that, in the case of various plants growing in association, the number of individual plants within a given area is generally small in

proportion as the number of species is also small. The diminution not only in the number of species, but in that of individual plants, is usually the result of conditions favouring the luxuriance of some species more than others; and hence the competition between plant and plant becomes more severe. The variety and the number are reduced, but the strength and size of those which remain are enhanced. The experimental details given in the sequel will afford some striking illustrations of these facts.

NAEGELI* considers the internecine war to be the most severe between those species and varieties which are the most nearly allied in character and organisation, because they require the same conditions of existence. He cites in illustration the case of three species of *Achillea*, two of which, *A. moschata* and *A. atrata*, make similar demands on their environment, and so come into competition one with another, with the result that the two are rarely found together, because one overpowers the other. The third species, *A. Millefolium*, having a different organisation from the other two is not brought into competition with them because its requirements are different; and it is, in consequence, found growing with either or both of the others. It must be remembered, however, that plants very closely allied morphologically, so far as their outward conformation is concerned, may, nevertheless, vary greatly in physiological endowments. We see this in the very varied constitutional and physiological peculiarities sometimes manifested in seedlings derived from the same parent plant. We shall hereafter have to dwell at length on the marked physiological diversities between two nearly allied species of *Poa*, *P. trivialis* and *P. pratensis*, as also between three species of *Avena* already mentioned, but in these cases there are structural differences between the species which indicate a more distant relationship between them than is apparent at first sight.

NAEGELI further alludes in some detail to the manner in which the preponderance of one species and the consequent ultimate extinction of another nearly allied form may be brought about. "It might be assumed," says NAEGELI, "that this result would always take place, and that one of two plants would always be crowded out, because the two could hardly be precisely equally hardy. But this conclusion would be unsound, because it would hold good only for plants whose conditions of existence were as nearly as possible alike. We can imagine another case in which the two species suffer injury from altogether dissimilar external influences (one, *e.g.*, from spring frost, the other from dry heat,) so that sometimes the number of individuals of one species, sometimes that of the other species diminishes, and where, moreover, the production and the germination of the seeds are affected by altogether dissimilar external influences, so that sometimes the one, sometimes the other species, increases most rapidly and occupies the vacant spots. The numerical proportion of the two species must in this case be variable, but neither is able to expel the other." The fluctuations from year to year of particular species on some of the plots at Rothamsted will afford similar illustrations.

* Sitzungsb. der K. Bay. Acad. der Wissensch., Dec. 15, 1865. See also SACHS' 'Text Book,' English edition, 1875, p. 833.

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Not only may the varying mechanical or chemical nature of the soil influence the issue of the struggle, but also the varied requirements of plants as to water, light, and heat. NAEGELI gives some examples of this. When *Primula officinalis* and *P. elatior* occur together in the same district they are sometimes sharply separated from one another; *P. officinalis* preferring the dry, *P. elatior* the damp spots. Each is most vigorous in its own special habitat, and may expel the other. But if only one species occurs in the district it is not so exacting; *P. officinalis* may then exist in damp, *P. elatior* in dry situations.

The influence, direct or indirect, that may be exerted by insects and other forms of animal life on the vegetation of the plots is too large a subject to be more than incidentally mentioned in this place. That influence may be detrimental or it may be favourable to plant growth or plant fertilisation; and its importance, from the latter point of view especially, has been more fully recognised since the publication of Mr. DARWIN'S observations and inferences; but the general question was not overlooked by LINNÆUS and the older naturalists, who recognised the interdependence of insects and plants, and pointed out how the equilibrium between the several classes was maintained.*

The foregoing illustrations will convey some idea of the manifold conditions affecting the competition between neighbouring plants. Plants growing in association are subjected to the competition of their immediate allies having the same requirements as to food, moisture, space, light, &c., or to the more active antagonism of less nearly related plants, which, though making somewhat different demands on the environment, yet overcome their neighbours by their superior hardiness or force of growth. Or the equilibrium may be disturbed by causes external to the plants themselves. On the other hand, plants may grow together in comparatively peaceful association, because their requirements are different, or because the conditions are so unfavourable for the luxuriance of any in particular that many exist on somewhat equal terms of limited growth.

The competition may be chiefly among the roots which form a network more or less dense and to a greater or less depth, according to the particular plant. The roots extend or ramify at different angles, and in different directions and to varying depths, according to the mechanical, chemical, and hygroscopic qualities of the soil. Just beneath the surface are the rootstocks, firm and more or less woody, jostling their neighbours, and pushing them aside, or emitting slender creeping stolons to twine their devious course among other plants. Or the competition may be chiefly above-ground. The dense tufts of some grasses occupy the surface, and prevent the growth of neighbouring species. In other cases, the creeping stems, the offsets, the runners—a hundred different forms and adaptations, provided for the benefit of the individual plant, as weapons of offence or defence, or as store houses for nutriment—contribute to the result. So again, also, is it with the form, the arrangement, the development of leaves, and also of the flowers and seeds. Indeed, the whole plant, in all its parts, and in all

* See Amœn. Acad., vi., *passim*, cited in LYELL'S 'Principles of Geology,' vol. ii., ed. 10, p. 436.

its functions, is better or worse adapted to the circumstances in which it is placed—the better, the more probable is its victory; the worse, the greater the probability that it will give place to others.

Absence or Predominance of Certain Species.—When in the discussion of the particular plants we speak of their absence from, or of their being driven out from, particular plots, our language must not be interpreted too strictly. Such statements, though based on careful observation on the plots during growth, and on botanical analysis of samples, are of necessity approximately correct only, for it can hardly be imagined, that in all cases of disappearance the plants are absolutely banished from the plot, either by the direct action of manures or by internecine conflict. They may be present, but in such diminished numbers, or in such limited growth, that they are not obvious on the plots at the times when the observations are made, and still less are they found in the samples. That this may be the case is shown by the fact that when circumstances become favourable they again appear. As has been said, many of the plants on the plots seldom, if ever, ripen their seed. The reappearance of such plants after an interval is not likely, therefore, to be due to the transport of seed. It is more probable that the root-stocks of such plants have all along existed on the plots, but, owing to unfavourable circumstances, have not been able to develop themselves. Some plants, it is well known—*e.g.*, some of the Orchids—have the power of maintaining an underground existence for several years, producing at most only a few minute leaves, and no flowers at all; so that their presence is not suspected till at length, in a favourable season, flowers are produced freely, and hundreds may be seen where the year before not one was observed. Such cases are familiar to botanists.

It is now generally recognised that the "characters" possessed by plants are either congenital—*i.e.*, ancestral, or physiological and adaptive. The former which are more particularly represented in the organs of reproduction are not subject to be changed by external conditions in short periods of time. Indeed, the hereditary tendency seems to preserve certain characteristics relatively unchanged, while, on the other hand, physiological characters (though of course also inherited) are much more liable to change under the influence of changed external conditions. As has been said, manures affect the degree of vigour of the foliage, roots, stems, &c., in a very marked degree; but they do not bring about any absolute difference in the nature of the organ or part affected. Certain characteristics are enhanced or degraded, as the case may be, but no absolutely new characters are engendered. The "struggle," dependent as it is partly on inherited and relatively invariable characters, and partly on other more pliable characteristics, can never be thoroughly appreciated until the structure of the plant, and its adaptation to the work it has to do, and to the conditions under which it has to do it, are better known.

Then as to the predominance of certain species, whilst some are more or less generally distributed on most or all of the plots, others are found only on some, and in

small proportion and amount. The "predominance," like the "absence," is determined by observation during growth each season, as well as by the less frequent botanical analyses of samples of the produce. By such observations and analyses a much more correct estimate of the actual degree of preponderance of individuals of particular species in a given area is gained than is indicated by the usual terms of "common," "rather common," "rare," "very rare," and the like, which give but a very imperfect idea of actual or relative predominance.* Moreover, the species predominant in one season are not necessarily so in another. We have, therefore, a means of studying the special influence of climate, of manures, or of the innate characters of the plant itself, which is of great value in the consideration of the struggle for existence among plants. If, for instance, in the same season a species is dominant on a great number of differently manured plots, it may be inferred that its dominance is due not directly to the agency of a particular manure, or to the climatal conditions alone, which were common to all the plots, but largely to the habit of the plant itself. The predominance of *Festuca ovina*, for instance, already referred to, and its tendency to spread, as shown by the circumstance that it was dominant in the first year of separation on two plots, in the second on eight, and in the third and fourth on thirteen, are obviously due rather to a superior power of endurance in the plant itself compared with its competitors, than to directly favourable conditions of manuring or of season. On the other hand, some species are dominant on some plots, but are absent from, or exist only in small proportions on others. In such cases it may be assumed that the particular manure has been either directly favourable or prejudicial to the plant, or indirectly so by favouring or discouraging the growth of others. Again, if a species be dominant on a particular plot, or on a group of plots more or less similarly manured, the inference is that the manure is directly beneficial to the plant.

The Grasses.

Passing to the consideration of the particular plants met with on the various experimental plots, first in order come the grasses, which constitute the most numerous and most important of their occupants.

Before describing the individual gramineous species occurring on the plots, it will be well to make a few general observations on them collectively.

The species which occur in the experimental field are, almost without exception, perennials, and they have generally a tufted habit of growth, especially under the influence of suitable manures. They have all more or less branched fibrous roots, consisting of a multitude of fine threads, which descend to various depths, and whose degree and manner of ramification vary according to the species, and to the conditions of manuring, association, and season. They never form a thick tap root, as some of the Leguminosæ and many of the miscellaneous plants do. Nor have they much

* See Alph. de Candolle, 'Géog. Bot.,' vol. ii., p. 1154.

tendency to form "store houses" for the accumulation of nutritive materials in the shape of tubers or other dilatations of the root or stem. Although some grasses, *e.g.*, *Alopecurus bulbosus*, have such organs, yet none of the species found on the plots have been observed to develop such formations, with the exception of *Alopecurus pratensis* and *Bromus mollis*, in which the formation of small tuberous swellings on the root fibres has occasionally been observed. Many grasses produce offsets, stolons, or runners, either below or just above the surface of the ground, by means of which they are enabled to establish possession of an extended area. The stems or culms of the grasses are usually erect and hollow, frequently tufted, and occasionally branched at the base, as in the case of the species which "tiller," such branches being of essentially the same character as the creeping shoots or stolons just referred to, but differing mainly by their erect direction and in their office.

"Adventitious" roots spring from the base of the culms in many cases, and are produced in abundance from the nodes or joints of the creeping shoots, especially under the influence of moisture.

The blade of the leaf differs considerably in form and dimensions in various grasses, and also according to season and conditions of manuring. The amount and character of the pubescence also varies according to locality and moisture, and, in a less degree, according to manure. For our purpose it may suffice to mention *Dactylis glomerata* as the type of the broad-leaved, and *Festuca ovina* of the narrow-leaved species.

The internal structure of the leaves, as elsewhere mentioned, though on the same general plan, varies in different species of the same genus, and even in the same species, according to locality and other circumstances.

It would be out of place to enter here into those details as to the conformation of particular plants which may be found in any text-book of descriptive botany. In the following sub-sections relating to the individual species, attention will be confined to those points of structure which appear to have more or less direct relation to the varying external conditions of season, soil, manuring, &c., to which the plants thus growing in association are subjected. Such structural characteristics are only treated of very generally in botanical works. They have, however, been made the subject of special observation at Rothamsted, and the more important points will be noted under the head of each plant. In like manner those physiological endowments and life-habits which appear to be of more or less importance to the plant in its struggle with its associates will be briefly alluded to, whilst others whose bearing on the subject is less obvious will be passed over.*

Anthoxanthum odoratum.

This fragrant perennial grass has fine, much branched, dense root fibres, forming a dense mat close to the surface, but not deeply penetrating. Its culms are tufted, erect, never creeping, 1 to 2 feet in height, and they bear flat, narrow, and ascending leaves. It begins to grow very early in spring and again soon after cutting, though it

* As to the fertilisation of grasses, see footnote at p. 1220.

yields but a scanty herbage. It is protogynous, and flowers so early that it is enabled to ripen seed before most other grasses. It is ordinarily found on dry pastures.

The characters specially favourable to it are its hardy constitution and its early growth, which enable it to occupy the ground before many of its associates, and to secure an early crop of seedlings. Its comparatively superficial roots enable it to avail itself of the food materials in the surface soil.

The following Table (XXXVII.) shows the plots upon which this grass was second or third (it was never first) in order of predominance (see p. 1227) *among the grasses* in either of the years of complete botanical separation: it also shows the actual percentages on those plots on which in the same years it yielded 5 per cent., or more, of the *total mixed herbage*.

In this and all subsequent tables of the kind relating to individual grasses, it is the *order of predominance* in the *total gramineous produce*, not in the *total mixed herbage of all orders*, that is represented. But as the total grasses predominate so uniformly over the species referable to all other Orders put together, and as, with only one exception, the grass which is first, second, or third among the grasses is also first, second, or third in the total herbage, the result would be practically the same in the tables relating to the grasses, whichever standard of predominance were adopted. As will be seen further on, however, it would be quite otherwise in the case of the Leguminosæ and of plants belonging to other Orders. The percentages are, however, those in the total mixed herbage. When a dash thus — appears in the tables the plots in question had not then been brought under experiment.

TABLE XXXVII.—Relative predominance of *Anthoxanthum odoratum*.

		Anthoxanthum odoratum							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	..	3	..	..	5·78	13·88
	2	..	..	..	..	..	..	6·67	7·20
	3	..	2	..	..	..	8·66	5·20	5·12
	4-1	..	3	..	..	..	7·16	..	5·11
	4-2	..	..	..	..	..	5·52	..	..
	5	..	3	3	3	5·77	5·51	..	..
	6	..	..	3	..	..	..	6·22	..
	8	..	3	3	..	..	6·98	7·94	7·55
	10	..	..	..	..	..	5·27	..	5·84
	12	..	2	3	..	..	7·66	6·67	5·47
	17	..	..	..	..	..	..	..	5·32
	18	—	..	..	..	—	..	7·11	8·64
	19	—	—	..	..	—	—	6·39	..
	20	—	—	..	..	—	—	7·17	..
Total	First	0	0	0	0	1	7	9	9
	Second	0	2	0	0				
	Third	0	3	4	2				

Thus in no single instance did this grass attain the first place. It was second in only one of the seasons (1867), and then only on the unmanured plots. It was third in the same year, and also in the subsequent separation years on the plots that were either unmanured or defectively manured; where, consequently, there was relatively little growth of the herbage generally, and little activity of struggle.

It yielded more than 5 per cent. on a larger number of plots, but did so in no case where the vegetation of its associates was generally luxuriant and healthy. It reached 7 to 8 per cent. in a few cases; but only once, and then only on a single plot, has it attained to nearly 14 per cent. This grass, therefore, only becomes prominent under conditions which do not induce special luxuriance in its competitors; and, on the Rothamsted soil, it seems to be more injured by association with more luxuriant grasses than by the direct action of manures.

In the Chiswick experiments, where *Anthoxanthum* was grown separately, it did not thrive so well as when grown in association, whether from want of shelter or from more rapid drying up is uncertain. Be this as it may, in one year the highest degree of vigour was observed where mineral manures and nitrate of soda were applied; in the second year where mineral manures and ammonia-salts were used. This result seems to confirm what has already been stated as to the effect of association on this plant; for when grown separately it would seem to thrive under conditions of manuring which when in association favour its competitors, and thereby limit its own luxuriance.

The observation made by GRISEBACH in his 'Vegetation der Erde' (1872), p. 150, is opposed to our ordinary experience with this grass. He states that he once saw *Anthoxanthum odoratum* dispossess almost all the other grasses in some thoroughly irrigated meadows. Irrigation doubtless tends to the simplification of the herbage, but it is opposed to general experience that a grass usually preferring dry situations, and one so unable to compete with others of more luxuriant habit, should thrive so remarkably under precisely opposite conditions.

Alopecurus pratensis.

This grass has a long, deeply-penetrating, more or less vertical subterranean root-stock, from which proceed creeping offsets or stolons, capable of giving off fibrils. In addition to the main vertical root fibres, there is usually, close beneath the surface, a dense leash of horizontal fibrils, which is however much less marked in the unmanured plots. On some of the plots a formation of small tubers on the fibrils has been noticed. The culms attain a height of 1 to 3 feet. The leaves are rather broad. It has not a tufted habit of growth, but grows in detached patches by the extension of its creeping, subterranean off-shoots. It is protogynous, flowers early, and often a second time. It withstands the severest frosts, and grows rapidly after mowing or grazing.

In this country it generally grows upon rather rich soils, and is injuriously affected by extremes of moisture or of drought.

The favouring conditions for its growth are: its hardiness, rapid, vigorous, and early growth, which enable it to get the start of its competitors. These qualities, combined with its deep roots and numerous subterranean offsets, cause it to spread rapidly, and to exhaust the soil for the smaller, less deeply-rooting grasses. Its early seeding tendency is also a favourable circumstance in its competition with others.

The conditions of its predominance are indicated in the following table.

TABLE XXXVIII.—Relative predominance of *Alopecurus pratensis*.

		Alopecurus pratensis							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	2	..	..	..	..	..	..	5·61	..
	3	..	..	..	..	..	5·82	..	..
	4–2	..	2	..	..	..	14·75	..	..
	10	..	..	..	2	..	..	10·35	16·51
	11–1	..	3	3	..	..	13·11	12·35	9·91
	11-2	..	..	2	2	..	6·33	22·65	20·11
	13	..	..	..	..	..	..	5·89	6·78
	14	..	..	..	2	..	..	..	20·18
	15	..	..	..	..	6·90	5·95	..	7·17
	16	..	..	2	..	..	8·27	15·22	12·23
	17	1	1	2	2	23·94	21·71	16·25	12·72
	19	—	—	..	..	—	—	..	5·40
	20	—	—	..	..	—	—	..	6·80
Total	First	1	1	0	0	2	7	7	10
	Second	0	1	3	4				
	Third	0	1	1	0				

It is seen that this plant was only first on plot 17, with nitrate of soda alone, and that only in the first two separation years. It occupied a second or a third place on plots all of which were more or less liberally manured; it was, indeed, second on three of the nitrate of soda plots.

It has exceeded 5 per cent. of the produce on an increasing number of plots from one separation year to another; and in the last it did so only on highly-manured plots, and especially on those with nitrate of soda. As is seen, it did not, on the majority of the plots, reach 5 per cent.; in fact, on many it was quite insignificant in amount; but under the influence of liberal manuring favourable to it, it reached from 10 to 15, and even to nearly 24 per cent.

From the foregoing results it appears that the deep and freely-rooting *Alopecurus pratensis*, with its numerous underground stolons, thrives best with high manuring, supplying much nitrogen. In this respect it comes into competition with *Dactylis glomerata*; which, however, maintains its prominence on the ammonia but not on the nitrate plots; whereas the *Alopecurus* does so on both the nitrate and the ammonia plots.

Agrostis vulgaris.

This is a very variable, tufted grass, emitting numerous stems, which creep along the surface of the ground, and produce roots and shoots at the nodes. The roots are exceedingly fine, much branched, and descend to a depth of 4 to 5 feet, but they also form a mat just beneath the surface. The root hairs are very abundant in damp situations, forming a dense white cobweb-like mass. The culms are slender, ascending, rooting at the base. The leaves are flat, narrow, and ascending. It flowers late in June and in July, and generally a second time in the autumn, and yields an abundant aftermath.

The characters favourable to its development are its hardiness and comparative indifference to the nature of the soil, its tufted habit, creeping stems and stolons, which enable it to extend itself, also its minutely branched roots, which gain extensive possession of the upper and richer layers of the soil.

The following table indicates its predominance on the various plots.

TABLE XXXIX.—Relative predominance of *Agrostis vulgaris*.

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		Agrostis vulgaris							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	1	1	..	6·45	20·77	23·53
	2	..	..	2	1	..	..	11·02	17·97
	3	2	3	2	2	11·36	8·63	16·14	13·28
	4–1	..	..	2	3	7·21	6·08	13·88	9·87
	4–2	1	3	2	2	19·38	14·00	20·59	24·39
	5	1	2	2	2	24·30	20·97	26·62	29·46
	6	1	2	2	3	21·43	14·41	23·37	8·58
	7	3	3	2	3	7·14	5·69	11·72	12·02
	8	2	..	2	3	10·01	..	9·32	12·40
	9	1	2	2	..	12·81	13·43	15·46	12·23
	10	..	..	3	3	9·37	8·61	14·17	16·29
	11–1	3	2	2	1	18·81	19·27	13·56	29·20
	11–2	2	2	..	..	13·17	24·16	10·16	17·09
	12	3	..	2	2	9·43	5·55	11·13	13·29
	13	2	1	2	2	12·02	20·35	13·44	13·40
	15	2	..	3	3	7·65	6·86	7·66	12·90
	16	2	2	3	2	12·49	13·62	12·40	14·58
	17	2	..	3	1	11·01	7·05	10·60	17·92
	18	—	2	2	3	—	7·29	21·95	16·40
	19	—	—	2	3	—	—	25·56	10·83
	20	—	—	1	3	—	—	31·35	10·36
Total	First	4	1	2	4	16	17	21	21
	Second	7	7	14	6				
	Third	3	3	4	9				

Of the 22 plots there is only one, viz.: that with the larger quantity of nitrate of soda and the mixed mineral manure (14), on which this plant has not been first, second, or third in order of prominence. It has been second much more frequently than first; indeed, more frequently so than any other species. It gained greatly in prominence up to the third separation year, 1872; and it has remained very prominent up to the present time, especially in the wetter seasons.

It has yielded more than 5 per cent. of the total produce on every plot except plot 14 (nitrate and minerals); and with very few exceptions it has done so in each of the four separation years. Indeed, in many cases it has formed a large proportion of the total herbage, amounting in a few to nearly 30 per cent. It is only very prominent where there is a liberal supply of nitrogen, under which condition its tufted habit becomes more conspicuous; but it is beaten by some freer-growing grasses where the manurial conditions are favourable to high maturation as well as to luxuriance. It is late in coming to maturity; and in a dry season is so backward that it scarcely flowers in the first crop. Hence, other things being equal, it yields a favourable percentage in the produce of different seasons. In 1870 it suffered greatly from the drought, but speedily recovered, even in the autumn of that year when the rain fell.

Holcus lanatus.

The roots of this grass do not penetrate deeply, but form a dense mat just beneath the surface. The rootstock has a slight tendency to creep. The culms are closely tufted, 1 to 2 feet in height, rooting freely from the lower nodes. The whole plant is more or less downy, and therefore perhaps less injuriously affected by frost or radiation.

It is moderately early, flowering in June and July, and again in the autumn. It yields a plentiful aftermath which, however, is said not to be relished by cattle. Under natural conditions it grows most freely in rather damp soils.

The characters favourable to its growth are its hardiness, its tufted habit, its tendency to produce roots from the base of the stems, and its densely-matted roots beneath the surface.

Table XL. shows the conditions of its predominance.

TABLE XL.—Relative predominance of *Holcus lanatus*.

		Holcus lanatus							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	2	2	2	..	10·70	14·06	17·55
	2	..	3	..	2	..	10·94	6·85	11·36
	3	..	..	..	3	5·04	7·97	..	12·55
	4–1	1	2	..	1	11·82	9·16	..	19·35
	4–2	2	..	..	3	16·21	10·53	..	6·03
	5	3	..	..	..	10·08	5·15	..	..
	6	..	..	..	2	8·17	..	5·31	14·89
	7	..	1	..	2	5·06	11·81	..	13·16
	8	..	2	..	2	..	10·25	..	18·22
	9	2	..	..	..	12·14	9·84	7·61	10·37
	10	..	..	..	..	9·50	8·24	..	..
	11–1	..	..	..	2	9·92	..	10·33	20·29
	11–2	..	..	..	3	7·37	..	10·59	19·48
	12	..	..	..	3	..	5·57	..	10·12
	13	..	..	..	..	5·35	..	..	..
	14	..	..	..	3	6·60	6·63	..	12·75
	15	3	3	..	2	7·61	11·81	5·32	14·95
	16	..	3	..	3	10·45	11·69	5·08	12·64
	17	..	..	..	..	8·23	8·13	5·87	10·91
	18	—	1	3	2	—	12·78	7·32	17·45
	19	—	—	3	2	—	—	14·03	21·19
	20	—	—	3	1	—	—	12·39	29·47
Total	First	1	2	0	2	15	16	12	19
	Second	2	3	1	9				
	Third	2	3	3	6				

This comparatively shallow-rooting plant has seldom attained the first place, and only on plots the manurial conditions of which do not tend to general luxuriance. It has been more frequently second; but only twice under conditions of high manuring, both nitrogenous and mineral, and of general luxuriance. It has also in some cases attained the third place, and in a few even where the growth was in a high degree luxuriant. The grasses which it has had chiefly to compete with under the circumstances have been *Agrostis vulgaris*, *Festuca ovina*, *Anthoxanthum odoratum*, *Avena pubescens*, and *A. flavescens*.

It has contributed more than 5 per cent. to the produce on the majority of the plots and in a greater number of cases in the fourth separation year than previously.

It has reached its highest percentage with liberal nitrogenous and mineral manures; but it has not, upon the whole, been largely developed on so many plots as either *Agrostis vulgaris* or *Festuca ovina*. It has only in a few cases contributed 20 per cent. of the total produce, but in one case nearly 30 per cent.

Avena elatior.

This tall-growing, tufted grass, has vertical, very deeply penetrating, fibrous, yellowish roots, densely covered with root-hairs, but not so much branched as in the case of the Poas. From the lower part of the culm, stout fleshy adventitious roots are often emitted, which form a close mat near the surface. The culms are 2 to 4 feet in height, and bear abundant foliage. It begins to grow early, and flowers in June.

The endowments favourable to the *Avena elatior* are its hardiness, its comparative indifference to the character of the soil, its particularly ample root growth, both deep and superficial, its strong tufted habit, and its early flowering tendency.

Its degree of predominance is shown in Table XLI.

TABLE XLI.—Relative predominance of *Avena elatior*.

		Avena elatior							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	6	..	3	..	..	..	6·50	..	..
	9	..	..	..	..	..	..	11·40	13·23
	10	..	3	..	..	..	11·71	13 22	9·58
	11-1	..	..	..	..	..	..	10·41	14·86
	11-2	..	..	3	1	6·40	..	12·73	21·14
	13	..	..	..	3	..	..	9·17	11·08
Total	First	0	0	0	1	1	2	5	5
	Second	0	0	0	0				
	Third	0	2	1	1				

Thus, *Avena elatior* only once attained to the first place, and only in the fourth year of separation, or 22nd year of the experiments; but then it did so on the most highly-manured plot of the series. In no case was it second; but on four occasions it took a third place on plots where there was liberal nitrogenous manuring, on two without, and on two with liberal mineral supply as well.

It was only in the two later separation years that this grass yielded more than 5 per cent. of the produce on as many as five plots, each of which was highly manured with ammonia-salts, and in four of the cases in conjunction with liberal mineral manuring. In only one case, but then with the highest manuring, both nitrogenous and mineral, did it contribute more than 20 per cent. of the total produce. It is strikingly deficient on the nitrate of soda plots. On the whole it has rather gained ground on the high ammonia and mineral plots, where also its tufted habit has been observed to be most developed.

Avena pubescens.

Avena pubescens has short, creeping, underground rootstocks, and fine thread-like roots, generally superficial, but having the power to descend to a great depth under favourable circumstances. Its tufted culms are few in number, 1 to 3 feet in height. The leaves are narrow, downy, especially on poor soils, but on richer ones the plant becomes glabrescent. It reproduces itself abundantly by means of its short underground stock. It begins to grow early, flowers in June, and ripens an abundance of seed.

The favouring conditions are its hardiness, tufted habit, free seeding tendency, and power of reproduction by its slightly creeping stock. Its degree of prominence is shown, in the usual form, in the subjoined table.

TABLE XLII.—Relative predominance of *Avena pubescens*.

		Avena pubescens							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	2	..	..	3	..	..	..	10·28	7·68
	3	3	..	..	..	9·65	..	..	..
	4–1	3	..	..	..	9·42	..	..	..
	4–2	..	..	..	..	7·38	..	..	..
	5	..	..	..	..	7·31	..	..	..
	6	2	..	..	..	14·54	..	..	..
	7	1	..	..	..	13·81	..	..	..
	8	1	..	..	..	12·68	..	..	..
	9	..	..	..	..	10·22	..	..	..
	10	2	..	..	..	10·64	..	..	..
	12	2	3	..	..	9·87	5·64	..	..
	13	..	..	..	..	5·48	..	..	..
Total	First	2	0	0	0	11	1	1	1
	Second	3	0	0	0				
	Third	2	1	1	0				

Thus, this plant only twice assumed the first place, then only in the first separation-year, and on plots where no nitrogenous manure was applied, and where, therefore, there was no general luxuriance of other grasses. It was three times second, but again only in the first year of separation, and again only on plots characterised by limited general growth. It was third twice in the first, once in the second, and once in the third separation-years; in each case without, or with deficient manuring.

In the first year of separation it yielded more than 5 per cent. of the produce on 11 plots, but on each succeeding occasion on one plot only.

Avena pubescens has, in fact, gone down under almost every condition of manuring

and has maintained moderate prominence only on a few plots where there was generally a very limited degree of luxuriance among its associates; its nearer competitors have been *Agrostis vulgaris*, *Festuca ovina*, *Anthoxanthum odoratum*, *Holcus lanatus*, and *A. flavescens*.

Avena flavescens.

Avena flavescens is a perennial, tufted grass, of rather weakly habit, with branched, fibrous roots, that do not descend deeply into the ground. The culms are few, slender, 12 to 24 inches in height. It starts into growth early, and flowers in June and July, and sometimes again in the autumn. It is chiefly found in cool dry pastures, and light soils.

The favouring conditions for the growth of the plant may be said to be its hardiness, and power of producing fertile seeds before the first cutting, which gives it an advantage over *A. pubescens*; but, on the other hand, its weak habit and absence of creeping shoots tell against it.

The following figures show its position as to degree of prominence.

TABLE XLIII.—Relative predominance of *Avena flavescens*.

		Avena flavescens							
		Was First, Second, or Third, among the total Grasses as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	..	..	..	6·85	6·23	..
	2	3	..	1	..	6·02	5·88	11·62	..
	4-1	..	..	3	..	..	..	6·09	..
	7	..	..	3	..	..	..	..	..
	8	..	..	..	..	5·42	..	6·94	..
	9	..	..	..	..	9·08	..	5·30	..
	10	..	..	..	..	10·05	..	..	..
	11-1	..	..	..	..	5·28	..	..	..
	14	..	..	3	..	..	7·12	5·67	..
	16	1	1	1	..	18·37	14·86	18·80	6·67
	18	—	..	..	..	—	..	5·75	..
	20	—	—	..	..	—	—	..	5·30
Total	First	1	1	2	0	6	4	8	2
	Second	0	0	0	0				
	Third	1	0	3	0				

On only two plots did *Avena flavescens* attain the first place; once on the plot which had formerly received farm-yard manure, but which had then been nine years without manure; and three times on plot 16 with the smaller amount of nitrate of soda and the mixed mineral manure. In no case did it come second. It was only on four

occasions third; once on the plot then receiving farm-yard manure, once with superphosphate of lime alone, and once with the complete mixed mineral manure alone, but once also with the larger amount of nitrate of soda and the mixed mineral manure.

It contributed more than 5 per cent. to the produce six times in the first separation year, only four times in the second, eight in the third, and only twice in the fourth. The conditions under which it has most conspicuously maintained its position are where both nitrate of soda and mineral manure was employed.

It attained to between 11 and 12 per cent. in 1872 on the plot which had formerly received farm-yard manure, and it reached nearly 19 per cent. in the same year, on the plot with the mineral manure and the smaller amount of nitrate of soda. On no other plot has it shown any marked prominence.

Of the three species of Avena, *A. elatior* is the only one that may be said to have gained ground on the experimental plots; and it has done so were there was liberal nitrogenous manuring, in the form of ammonia-salt, with mineral manure in addition. Both *A. pubescens* and *A. flavescens* have, on the other hand, gone down; and neither of them has maintained even moderate prominence where ammonia-salts were used; but both, and especially *A. flavescens*, have been more favoured under the influence of the nitrate.

The comparatively robust habit and superior physical endowments of *A. elatior* are sufficient to account for its superiority over its congeners when growing in association. It may here be remarked that many botanists place *A. elatior* in a distinct genus—*Arrhenatherum*, by reason of the lower flower of each spikelet being male only, and also from the presence of certain rudimentary organs, indicative of a different line of descent of this plant from the true Avenas.

Poa trivialis.

This plant has closely matted minute fibrous roots, not penetrating deeply, but forming a dense mat beneath the surface, producing no underground offshoots, but developing, especially in moist weather, creeping branches from the base of the culms. The culms are tufted, 1 to 2 feet in height, rather rough, and bear linear leaves, narrower than those of *P. pratensis*. It is early in growth, though rather tender, and liable to injury from frost or drought. It grows rapidly, flowers in June, and again in the autumn. It seeds abundantly in the first crop, especially on plot 14 (mineral and high nitrate), where numerous seedlings have been observed. Like *P. pratensis* it prefers a moist rich soil.

The endowments propitious to the growth of this plant are its dense root-development, its rapid growth under favourable conditions as to soil, manure, and moisture, its formation of stolons, and its free seeding tendency.

Table XLIV. registers its characters as to predominance.

TABLE XLIV.—Relative predominance of *Poa trivialis*.

		Poa trivialis							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	1	1	..	..	31·90	22·32	..	..
	2	1	2	..	..	28·18	15·75	..	..
	4-1	..	..	..	..	5·16	5·65	..	..
	4-2	3	..	..	..	8·14	..	..	..
	8	..	..	..	..	5·48	..	..	..
	9	..	..	..	..	8·72	..	..	..
	10	3	..	..	..	10·18	..	..	..
	11-1	2	..	..	..	13·25	..	..	..
	11-2	3	..	..	..	17·04	..	..	..
	13	3	..	..	..	11·84	6·68	..	..
	14	1	1	2	1	22·48	32·93	24·76	21·59
	15	..	1	2	..	6·53	23·67	7·95	6·05
	16	..	..	..	..	6·87	8·96	6·53	..
	17	..	2	..	..	5·21	12·08	..	..
Total	First	3	3	0	1	14	8	3	2
	Second	1	2	2	0				
	Third	4	0	0	0				

This Poa has only been first on four plots: on the two dung plots in 1862, and on one of them in 1867, after the discontinuance of the manure, but on neither since. It has three times been first on the plot with mixed mineral manure and the larger amount of nitrate, and once on the plot with the same amount of nitrate without minerals. It was second on one of the high ammonia and mineral plots in 1862, and in the same year it was third on four other ammonia plots. In 1867 it was second only on the dung plot and on one of the nitrate plots. Since that date it has been neither first, second, nor third on any of the ammonia plots. In 1872 it was second on two of the nitrate plots, but in the last year of separation it was first on only one—a nitrate plot, and not second nor third on any.

The number of plots on which it contributed 5 per cent. and upwards of the produce was 14 in 1862, only eight in 1867, and was reduced to three in 1872, and to two in 1877. The plots on which it maintained this degree of prominence were all nitrate plots. In fact, although at first extremely prominent on many plots it strikingly declined wherever ammonia was applied, and almost as strikingly retained its position on the plot with the mineral manure and the larger amount of nitrate of soda (14); yielding on it 22·48 per cent. of the total produce in 1862, 32·93 in 1867, 24·76 in 1872, and 21·59, in 1877; whilst in 1874 it was estimated to form about one-half of the total herbage of the plot.

Poa pratensis.

This grass, in addition to its tufted stems, has numerous underground stolons, which form new plants at their extremities. The roots, which are given off from the short underground stems as well as from the stolons, are fibrous, intricately branched, not penetrating very deeply, but forming a dense mat beneath the surface. The culms are 1 to 4 feet in height, erect, and smooth. The leaves are broadish. It begins to grow early in spring, which is advantageous on economic grounds, and it grows also rapidly after cutting. It flowers in June. It is found usually on rich, somewhat damp or shaded soil, but it is by no means confined to localities of this description.

This grass possesses advantages in its hardihood, free growth, its development of stolons, its dense root growth, its power of growing early, and again after cutting, &c. It is stated, however, to be particularly liable to the attacks of a fungus ("rust" or *Puccinia*).

Table XLV. records the relative degree of predominance of this species.

TABLE XLV.—Relative predominance of *Poa pratensis*.

		Poa pratensis							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	3	..	..	6·56	7·41	..
	4-2	..	..	3	..	..	..	5·11	..
	9	3	3	1	2	10·68	13·02	22·67	18·03
	10	..	1	2	..	..	14·81	19·62	6·48
	11-1	..	..	..	..	9·43	12·86	10·40	..
	11-2	..	3	..	..	5·12	10·38	12·43	..
	13	..	3	3	..	..	10·26	11·45	10·09
Total	First	0	1	1	0	3	6	7	3
	Second	0	0	1	1				
	Third	1	3	3	0				

On only two occasions did *Poa pratensis* take the first place among grasses, on one plot in 1867, and on one in 1872, both manured with ammonia-salts and mineral manure. On each of the same two plots it was also once second. It came third rather more frequently, but in each case where ammonia-salts were applied in conjunction with mineral manure.

It was again only on the ammonia plots that it exceeded 5 per cent. of the total produce, and maintained its position in that respect; and it did so the most markedly where the ammonia-salts were used in the smaller quantity; other free-growing

grasses overcoming it where the larger quantity of ammonia was employed. This was especially the case in the later years.

In only one instance did it yield more than 20 per cent. of the total produce, and then it was with the mixed mineral manure and the smaller quantity of ammonia-salts. On each of the nitrate plots, on the other hand, it occurred in only insignificant amount.

Comparison between the two species of Poa.—From what has been said of the two species of this genus, it is evident that the stolon-bearing *Poa pratensis* is specially benefited by nitrogenous manure in the form of ammonia-salts (in combination with mineral manure), but not at all by nitrate of soda; whereas the more finely rooted and non-stoloniferous *Poa trivialis* has declined markedly on the ammonia plots, but has remained very prominent on the nitrate plots, especially where the larger amount of nitrate was used with the mixed mineral manure. This is strikingly illustrated in the following summary table, giving side by side the percentage (in the total produce) of each of the two Poas on two comparable plots; plot 9 with mineral manure and nitrogen as ammonia-salts, and plot 14 with the same mineral manure and the same amount of nitrogen, but as nitrate of soda. It may be added that there is the same contrasted tendency of the two species to increase or decrease respectively on the other ammonia and nitrate plots of the series.

TABLE XLVI.

Separation years.	Plot 9. Mineral Manure and Ammonia Salts.		Plot 14. Mineral Manure and Nitrate of Soda.	
	Poa pratensis.	Poa trivialis.	Poa pratensis.	Poa trivialis.
	Per cent.	Per cent.	Per cent.	Per cent.
1862	10·68	8·72	1·45	22·4·1
1867	13·02	2·14	1·05	32·93
1872	22·67	0·64	2·57	24·76
1877	18·03	0·11	4·01	21·59

The interesting question arises whether the relatively shallow-rooting *Poa trivialis* predominates on the nitrate plots by reason of its fine surface roots arresting and taking up the nitrate before it has had time to penetrate too deeply. This view is favoured by the fact of the rapid growth which this plant invariably makes upon the application of the nitrate of soda in the spring. Another point worthy of remark is the contrast observable on plot 14, between the shallow-rooted *Poa trivialis* and the deeper and wiry-rooted *Bromus mollis*. In moist seasons, when the latter is relatively deficient, *Poa trivialis* is luxuriant, and *vice versâ*.

Dactylis glomerata.

This is a robust, free-growing grass, with strong, stout, fibrous roots, descending more or less vertically to a considerable depth, and together with other more horizontally disposed fibres matting the soil into a dense ball. The root-hairs, under favourable circumstances, are numerous, long, and delicate. In some cases we have observed the root fibres protruding from the base of the tufts, and ascending for 2 to 3 inches before they could find an outlet through which to descend to the soil. The stock is more or less tufted, especially so when well developed, as on the ammonia plots. The culms are 2 to 3 feet in height. The broad leaves vary greatly in colour and luxuriance, according to the manure. The plant flowers in June and is dichogamous. It makes growth by means of offsets from the base of the last year's stems, early in spring, and again after cutting or browsing. Hence it is valued as a pasture grass, but if allowed to grow too old it becomes too woody, and is then of less value as food. It grows in almost any soil, but shows a preference for those which are rich, and is considerably different in habit and appearance on different soils; the "hummocky" habit being specially noticeable where the food is abundant.

The circumstances favouring the success of the plant are—its robust constitution, general luxuriance and power of adaption; its deeply-penetrating, abundant and greatly branched root fibres; its densely tufted habit, and its growth after cutting or browsing.

Table XLVII. shows its predominance.

TABLE XLVII.—Relative predominance of *Dactylis glomerata.*

		Dactylis glomerata							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	3	..	..	..	16·43	6·43	..	..
	2	..	..	..	..	..	6·51	..	..
	9	..	..	3	3	5·58	..	11·88	14·07
	10	1	..	..	..	12·51	5·44	..	..
	11–1	1	1	1	3	24·16	39·31	39·28	17·11
	11–2	1	1	1	..	23·34	38·30	27·23	13·38
	13	1	2	1	1	27·88	20·29	43·05	40·75
	14	..	..	..	..	10·00	7·28	..	12·48
Total	First	4	2	3	1	7	7	4	5
	Second	0	1	0	0				
	Third	1	0	1	2				

Thus, *Dactylis* was first on four plots in 1862, on two in 1867, on three in 1872,

and on one in 1877. Each of the plots on which it was so received ammonia-salts and mineral manure together. It was second on one of the same plots in 1867. It was third on one ammonia plot in 1862, on one in 1872, and on two in 1877. It has thus asserted itself only under the influence of liberal supplies of ammonia, in conjunction with mineral manure. It yielded 5 per cent. and more to the produce on seven plots in 1862, on seven in 1867, on four in 1872, and on five in 1877. The only plots on which it has been so far prominent in the two latter separation years are those receiving nitrogenous with mineral manures. But the only plots on which it has contributed a really large proportion of the herbage are those where the nitrogenous manure was in the form of ammonia-salts, and where there was liberal application of mineral manure as well. Even on some of these plots the plant has not been so prominent in recent years as formerly. Thus, whilst on one of the plots having the double amount of ammonia-salts and mineral manure, the *Dactylis* yielded nearly 40 per cent. of the produce in 1867 and in 1872; on the same plot it only furnished 17 per cent. in 1877. Again, on the other double-ammonia plot it declined from 38·3 per cent. in 1867, to 27·23 in 1872, and to 13·38 in 1877. The only plot on which it has yielded excessively in the more recent years is the one (13) with ammonia salts, mineral manure, and cut wheat straw, where it gave 27·88 per cent. in 1862, 20·29 per cent. in 1867, 43·05 per cent. in 1872, and 40·75 per cent. in 1877. On the other hand, it always occurs in very much less amount, and generally in quite insignificant quantity, where the nitrate of soda is used. In a word, it is really prominent only with a liberal supply of ammonia, associated with a correspondingly liberal supply of mineral constituents, together favouring general luxuriance, much stem formation, and tendency to mature.

Owing to the dense hummocky mode of growth of the *Dactylis* on plots suitable to its development, and to its deep roots, it is a formidable opponent to other grasses, where it has once got possession. But it is at a disadvantage in competition with the shallow, densely-matted roots of *Poa trivialis*, and the quick-growing, close stemmed, *Bromus mollis*. On the unmanured plots it is but of weakly habit, and is relatively deficient in the mat of roots beneath the surface, and in the dense tufts, which it produces under conditions of high manuring.

Festuca ovina.

This is a perennial, densely-tufted grass, often provided with numerous fine, creeping, underground stolons, by means of which the plant is widely spread, especially where the flowering tendency is restricted. The root fibres are very numerous (relatively more so than in any other grass on the plots), fine, with but few hairs, branching in all directions, and forming a very dense network just beneath the surface, thereby obtaining full possession of the soil to a depth of from 6 to 10 inches, but not usually penetrating more deeply. The culms are slender, angular, 6 inches to 2 feet in height,

and decumbent at the base, giving off roots from the under surface. The leaves are mostly radical, very slender, erect, conduplicate, varying in colour and size. The plant flowers in June and July, and again in the autumn.

The form usually met with in the experimental plots is called *F. duriuscula*, which is larger than the typical *F. ovina*, and its upper leaves are flat, not folded. Some botanists have considered that there are several varieties of *F. ovina*, whilst others have ranked them as separate species. That considerable differences exist is obvious, but it is equally obvious that these differences are by no means so great as to preclude the idea that they may all have originated from a common stock. SINCLAIR ('Hortus Gramineus Woburnensis,' p. 155, 8th ed.) says, and his opinion is worthy of great consideration, that, "All these grasses (*F. glauca*, *glabra*, *cambrica*, *duriuscula*, and *rubra*) vary much from change of soil and situation; the flowers are particularly apt to vary in number, as well as in the length of their awns; there is one character, however, which I have never found to change under any variety of culture, which is the creeping root; and this is also an agricultural character of distinction which is never to be lost sight of, as it always produces a specific effect upon the soil, very distinct indeed from that of the fibrous rooted kinds."

The records of observation at Rothamsted do not enable us to speak so decidedly as SINCLAIR does as to the permanence of the character afforded by the "creeping root." According to him it is the form called *F. rubra* alone which possesses this characteristic, while the fine *F. ovina*, and its allies, or varieties, *duriuscula*, *glabra*, *cambrica*, do not show it. We are inclined to look on the "creeping root" as to a large extent an induced physiological character, depending on conditions of soil and competition, &c., and not as a permanent hereditary characteristic; and this seems to be the view of Mr. BENTHAM and Sir JOSEPH HOOKER, neither of whom admit the forms above mentioned to higher rank than that of sub-species or varieties. On the unmanured plots the form met with corresponds most closely with the typical *F. ovina*; while on the highly manured plots greater development and luxuriance is met with, and the plant assumes more of the habit of *F. duriuscula*.

In this country the grass is very abundant at all elevations, especially on dry poor soils. It is subject, under varying external conditions, to great variations in size and colour of parts, presence or absence of awns, &c.

The characters favourable to it are its dense rooting faculty, its tufted habit, abundant and fine offsets, threading their way among other roots, fine slender leaves, capable of expanding or closing according to hygroscopic conditions, enabling the plant to insinuate itself among its competitors, &c. Its restricted evaporating surface, robust constitution, and power of adaptation to diverse circumstances, as shown by its world-wide distribution, also give it a great advantage. Its ability to withstand drought is likewise a faculty greatly in its favour in dry seasons.

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TABLE XLVIII.—Relative predominance of *Festuca ovina*.

		Festuca ovina							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	..	..	..	6·17	6·40	10·75
	2	..	..	..	3	..	..	9·89	11·23
	3	1	1	1	1	13·30	15·20	21·67	21·89
	4–1	2	1	1	2	10·20	16·75	20·44	16·02
	4–2	..	1	1	1	6·80	26·09	49·29	55·20
	5	2	1	1	1	21·99	30·57	46·56	53·31
	6	3	1	1	1	13·33	25·93	31·15	38·02
	7	2	2	1	1	13·73	11·38	14·86	26·59
	8	3	1	1	1	7·51	17·74	23·95	19·76
	9	..	1	..	1	5·21	18·42	8·68	21·80
	10	..	2	1	1	..	14·74	19·80	26·34
	12	..	1	1	1	7·17	11·59	16·05	20·88
	13	..	..	..	..	..	6·86	..	..
	15	1	2	1	1	13·69	12·08	34·71	20·77
	16	3	..	..	1	11·13	10·44	10·33	16·66
	17	3	3	1	3	9·43	11·18	18·05	12·04
	18	—	3	1	1	—	7·05	23·76	24·65
	19	—	—	1	1	—	—	29·65	21·40
	20	—	—	2	2	—	—	25·54	18·69
Total	First	2	8	13	13	12	16	18	18
	Second	3	3	1	2				
	Third	4	2	0	2				

Thus, *Festuca ovina* gave the highest percentage in the total gramineous herbage on two plots in 1862, on eight in 1867, on 13 in 1872, and on 13 in 1877. It was second on three plots in 1862, on three in 1867, on one in 1872, and on two in 1877. It was third on four plots in 1862, on two in 1867, on none in 1872, and on two in 1877. It is clear, therefore, that this very poor, "common-land," but hardy and drought-resisting grass, has gained in prominence in a very marked degree on some plots during the progress of the experiments. It has only lost in second and third place to gain the first in the later years. It was first, second, or third on nine plots in 1862, on 13 in 1867, on 14 in 1872, and on 17 in 1877. It yielded 5 per cent. and over of the total produce on 12 plots in 1862, on 16 in 1867, on 18 in 1872, and on 18 in 1877.

The only other grass which has shown anything like such general prominence is *Agrostis vulgaris*; but although the latter has been more frequently first, second, or third, especially more frequently, and increasingly, second or third, it has been much less frequently first than *Festuca ovina*. *Agrostis vulgaris* has also yielded more than 5 per cent. on a greater number of plots in each separation year than the *Festuca*, but it has by no means contributed so high a percentage on some plots. Thus, on plot

4- 2 (ammonia and superphosphate) *Festuca ovina* contributed 49·29 per cent. in 1872 and 55·20 per cent. in 1877: and on plot 5, with ammonia-salts alone, it gave 46·56 per cent. in 1872, and 53·31 per cent. in 1877; whereas *Agrostis vulgaris* has in only one case exceeded 30 per cent. The table shows that *Festuca ovina* was neither first, second, nor third on either plot 11–1, 11–2, 13 or 14, the four plots of the highest luxuriance of gramineous herbage, and especially of the freer-growing species. *Agrostis vulgaris*, however, contributed a much higher proportion of the produce on these plots (excepting 14) of high gramineous luxuriance, and maturation also, than did *Festuca ovina*.

The general result is, that *Festuca ovina* has gained in prominence on all the deficiently or only moderately manured plots; and it has done so the most, other things being equal, where, with a sufficiency of nitrogenous manure favouring gramineous luxuriance, there has been a deficiency of mineral supply preventing maturation, and consequently limiting the power of competition, of the freer-growing grasses. In fact, where the *Festuca ovina* has yielded the highest percentage of the produce, it has been with low total yield, and with a very large proportion of dark green, leafy, immature growth. The *Festuca ovina* also gains where other plants suffer for want of moisture; whilst the *Agrostis vulgaris* gains (if the other conditions are favourable to it) in the wetter seasons.

Festuca pratensis.

The stock of this grass is subterranean, perennial, somewhat creeping, but rarely producing offsets. The culms are tufted, 2 to 4 feet high; the leaves flat and broadish. The root fibres penetrate more deeply than those of *F. ovina*, but are not so much branched. It begins to grow somewhat early and rapidly, and flowers in June.

In this country this grass is partial to rich, moist soils, and is said to be an excellent pasture grass, much relished by cattle. It varies in stature, form of inflorescence, and presence or absence of stolons. *F. elatior*, sometimes considered a variety of this, has more stolons, and a more spreading flower-panicle.

This species of *Festuca*, instead of being first, second, or third in prominence on a large number of plots, and yielding in some cases half of the entire produce as did *F. ovina*, in only one case was first, and that was on the unmanured plot (12), in the first separation-year, 1862; and it was only on that occasion that it yielded more than 5 per cent. of the produce. On some plots in the first separation year it was absent, but on most it occurred in only small quantity; and on almost every plot it has gone down to a quite insignificant amount. The only plot on which it persistently gained is 15, with nitrate of soda alone up to 1875 inclusive, and the mixed mineral manure, including potass, each year since; and even there it only contributed 1·47 per cent. of the produce in the fourth separation-year.

Festuca elatior has only been found in the sample from one plot, and then in very insignificant amount.

Festuca loliacea, which is hardly more than a variety of *F. pratensis*, has only been found in the samples from two plots, and, like *Festuca elatior*, in quite insignificant quantity.

As compared with *Festuca ovina*, which is one of the most prevalent grasses on the plots, *F. pratensis* is rapidly and greatly diminishing. This may possibly arise from the fact that *F. pratensis* is not so hardy as *F. ovina*, is less sturdy in habit, has a less branched root-growth, fewer stolons, a greater evaporating surface from its broader leaves, which, together with its less extensive root-development, may afford a reason why *F. pratensis* does not resist drought so well as *F. ovina*.

Bromus mollis.

This grass is annual or biennial; all the other grasses on the plots being perennial. Its roots are stiff, wiry, not much branched, but sometimes very deeply penetrating. On plot 14 (nitrate and mineral), the roots were discovered at a depth of 4 to 5 feet, having lost their wiriness and become fleshy. Small tubers were also observed on the root-fibres at the depth of 9 inches, and more; the tubers measuring sometimes as much as a quarter of an inch in length. The culms are 1 to 3 feet high, and generally die away after seeding or cutting, when new growth, but not so highly developed, is formed from the stock. If constantly mown or fed off, it generally disappears. It flowers early, so that its seeds ripen before cutting, and many seedlings are produced.

The endowments favourable to it are its deeply rooting powers, which enable it to withstand drought, the tubers probably aiding as a store; also its abundant and early production of seed, which enable the plant to diffuse itself freely when circumstances are propitious.

The following table shows its predominance.

TABLE XLIX.—Relative predominance of *Bromus mollis*.

		Bromus mollis							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent., and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	2	3	..	..	21·92	10·55	..	..
	2	2	1	..	..	17·77	16·39	..	..
	14	2	2	1	..	18·04	17·69	42·10	8·02
	15	..	..	..	..	..	6·27	..	..
Total	First	0	1	1	0	3	4	1	1
	Second	3	1	0	0				
	Third	0	1	0	0				

The position of this plant on the experimental plots is very marked. It was not first on any of the plots in 1862; but in that year it was second on plots 1 and 2, the first with farmyard manure and ammonia, and the second with farmyard manure alone. In 1867, however, it had reached the first place on plot 2, with farmyard manure alone up to 1863 inclusive, but no manure since; and it was third on plot 1, where the farmyard manure and ammonia-salts had been applied up to 1863, and the ammonia-salts alone since. On neither of these plots was it either first, second, or third in either 1872 or 1877; nor did it reach 5 per cent. of the produce in either of these two later separation-years. On plot 1 (dung and ammonia-salts the first eight years) it yielded 21·92 per cent. in 1862, 10·55 per cent. in 1867, 4·55 per cent. in 1862, and only 0·83 per cent. in 1877. On plot 2, again (dung alone the first eight years and no manure afterwards), it went down from 17·77 per cent. in 1862, to 16·39 per cent. in 1867, 3·89 per cent. in 1872, and to only 0·18 per cent. in 1877.

As the table shows, on only one other plot (14), with the larger amount of nitrate of soda and the mixed mineral manure, did it attain to the first or second place; and it was only on that plot that it yielded more than 5 per cent. of the produce in each of the four separation-years. Indeed, here it gave 18·04 per cent. in 1862, 17·69 per cent. in 1867, 42·1 per cent. in 1872, but only 8·02 per cent. in 1877. In 1870, however, the year of extreme spring and summer drought, plot 14 yielded an enormous crop of *Bromus mollis;* estimated at half, or more, of the total produce. In 1871, again, this plant was estimated to yield the greater part of the crop on this same plot (14), owing probably in great part to the large number of seedlings produced in the previous year. As more fully discussed in Part I., p. 334, *et seq.*, the predominance of *Bromus* on this plot, in years of drought, is attributed to its wiry and deep roots gaining possession of the lower layers of the soil, and thus rendering it comparatively independent of surface moisture, and able to arrest the deeply percolating nitrate. Its chief rival on the plot is *Poa trivialis*, especially in wet seasons; whilst on the plots with the same mineral manure, and the same amount of nitrogen, but supplied as ammonia-salts, *Bromus mollis* occurs in very insignificant amount, *Poa trivialis* is in much less amount than *Poa pratensis*, and *Dactylis* and other free-growing grasses attain a high place.

It should be observed that plot 14, on which such large quantities of *Bromus* occur, is contiguous to plot 1 on one side, and to plot 15 on the other; so that its freer occurrence on those plots than anywhere else, excepting on plot 14, may in part be accounted for by this circumstance. Upon the whole, *Bromus mollis* has somewhat gone down on plot 14 in the later, frequently wet years; *Poa trivialis*, as already said, proving its most successful rival, and *Alopecurus* coming next. It remains to be seen whether *Bromus*, a plant of evil reputation with the farmer, will not re-assert itself in years of comparative drought.

Lolium perenne.

The culms of this grass are more or less tufted, 1 to 2 feet high, decumbent, and subterranean at the base, then ascending, rooting at the nodes, and giving off leafy stolons. The roots are much branched, fibrous, penetrate to a considerable depth, and give off a dense network of root-fibrils near the surface. The root-hairs are stoutish, sometimes short, numerous; at other times very fine and intricate.

This grass shoots early, flowers in May and June, and again in the autumn; and it is observed to grow well after trampling down or cutting, and to vary greatly in character according to external conditions. It is most favoured by a moist, warm season. Mr. WHITWORTH is recorded by SINCLAIR to have collected as many as 60 varieties. It does not produce much aftermath.

The endowments specially favourable to it are its hardiness, creeping offshoots, growth after cutting, &c.

TABLE L.—Relative predominance of *Lolium perenne*.

		Lolium perenne							
		Was First, Second, or Third, among the total Grasses, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	3	..	..	..	..	6·37	..	..	..
	4–1	..	..	..	..	9·28	5·24	..	..
	4–2	..	..	..	..	6·47	..	..	..
	8	..	..	..	..	5·92	..	..	7·63
	14	3	3	..	..	13·80	9·36	5·55	..
	15	..	..	..	..	7·49	..	..	7·32
	16	..	..	..	..	5·85	6·23	..	..
	17	..	..	..	..	5·09	..	..	6·68
	18	—	..	..	..	—	5·15	..	6·45
Total	First	0	0	0	0	8	4	1	4
	Second	0	0	0	0				
	Third	1	1	0	0				

The table shows that this grass was neither first nor second on any plot in either of the separation-years; but it was third in the first two separation-years, 1862 and 1867, on plot 14, with the larger amount of nitrate of soda and the mixed mineral manure. It yielded more than 5 per cent. of the produce on eight plots in 1862, on four in 1867, on one only in 1872, but again on four in 1877. It was, nevertheless, found in greater or less quantity in the samples from every plot in each separation-year, excepting plot 11–1 in 1872, and 11–2 in 1877; these being the two plots most highly manured with ammonia-salts, in conjunction with mixed mineral manure. It will be observed that it yielded 5 per cent. and over to the produce on plot 3

(unmanured), on plot 4–1 (superphosphate alone) and 4–2 (superphosphate and ammonia-salts) in 1862, but only on one of them in 1867, and not again on either. On plot 8 (mineral manure, then without potass) it gave more than 5 per cent. in 1862, and again in 1877. But the most favourable conditions for it in the struggle are obviously those supplied on the nitrate of soda plots, on four of which it yielded more than 5 per cent. in 1862, on two in 1867, on one in 1872, and on two in 1877. This is consistent with the results obtained at Chiswick, where the plant was grown separately; and it was where the nitrate was applied that the root development of this plant was greatest. It also yielded somewhat more than 5 per cent. on plot 18, manured with the ash-constituents and the nitrogen of one ton of hay, in the second and fourth separation-years.

It will be observed, however, that, even on those plots the most favourable to it, there was generally a decline in the percentage amount of it from the first to the third separation-year, but generally some recovery in 1877, though not on the plot which upon the whole yielded the highest percentage, namely, plot 14, with the nitrate of soda and mineral manure; to the produce of which it contributed 13·8 per cent. in 1862, 9·36 per cent. in 1867, 5·55 per cent. in 1872, and only 2·63 per cent. in 1877, whilst on several other plots it yielded a higher percentage than this in 1877, and on some between 6 and 8 per cent.

It is obvious that *Lolium perenne* is a plant of relatively weakly habit, and that it did not flourish where ammonia-salts were used, but that where the nitrogen was supplied as nitrate of soda, it was much more able to maintain some, though still a rather low position in the struggle. This may be due either to a want of favourable manurial conditions for the plant itself where ammonia-salts are applied, or to the competition of stronger species being thus stimulated, whilst with the nitrate of soda, the favourable conditions for the plant itself have probably something to do with the results. When growing separately the plant is reputed to attain considerable luxuriance with liberal nitrogenous manuring, and plenty of moisture and warmth; and its partial recovery of prominence in the later years may be due to the prevailing wetness of the seasons.

There are certain other grasses which occur only on some of the plots, and then only in very small proportions, and which therefore demand merely passing notice.

Phleum pratense.—The *Cat's-tail*, or *Timothy grass*, occurs in moist pastures, and has a slightly creeping root which occasionally becomes bulbous, a tufted stock whence arise erect stems bearing cylindrical flower-spikes. It produces in spring an abundance of leaves at the base of the stems. This grass was observed on, or found in the samples from, six plots in 1862, five in 1867, six in 1872, and three in 1877. The plots on which it was found were for the most part those treated either with ammonia-salts or nitrate of soda, but in no case did it reach 0·2 of the total produce, and generally much less.

Aira cæspitosa.—The *Tufted-hair grass* is a large, coarse-growing grass, forming thick tufts or hummocks, which throw up tall stems bearing coarse foliage, and light panicles of flowers. It is a common plant in moist shady woods, and is abundant on Harpenden Common, though very sparingly represented on the plots. Its presence was noted on five plots in 1862, on three in 1867, on 17 in 1872, and on nine in 1877. It occurred in slightly greater proportionate amount on the ammonia and the nitrate plots, but in every case its produce was quite insignificant.

Briza media.—The *Quaking grass* is tufted, slightly creeping, and usually grows in dry open situations. It occurred in the samples taken from nine plots in 1862, in nine in 1867, in 17 in 1872, and in 12 in 1877. It was in largest proportion on the unmanured plots, on which it has on the whole increased, and in one instance it contributed more than 7 per cent. of the produce.

Of all the manured plots the one with superphosphate of lime alone was the most favourable to it, but even there it furnished little more than 2 per cent. of the produce. It was generally absent from the samples taken from the ammonia plots, or, if represented at all, it was in quite insignificant amount. It was, however, much more general, though still in very small quantity, where nitrate of soda was used. It would thus seem that ammonia-salts are either directly prejudicial to this grass, or that they are so indirectly, by favouring the more luxuriantly growing species.

Cynosurus cristatus.—The *crested Dog's-tail* is a tufted grass, the finely branched roots of which are reputed to penetrate deeply. It was found in the samples from, or observed during growth on, 14 plots in 1862, 14 in 1867, 16 in 1872, and 14 in 1877. It was absent, or in very small proportion, on the ammonia plots, but was generally present on the nitrate plots, and on those without mineral manure, or with mineral manure alone.

In one case where nitrate of soda was used it reached 2·54 per cent., and in three others it yielded more than 1 per cent. It also exceeded 1 per cent. on one occasion without manure, and in three with mineral manure alone; but in the large majority of the samples it was in very much smaller proportion.

It is obvious that neither of these four last-mentioned grasses was able to maintain even a moderate degree of prominence where the conditions were favourable for the luxuriance of other gramineous species.

The Leguminosæ.

Next in importance to the grasses in the mixed herbage of meadow-land are the leguminous plants. The species which occur on the plots all belong to the Papilionaceous sub-division of the Order, the only one indeed represented in temperate climates. They are all low-growing or trailing perennials, varying considerably in "habit" one from another.

The roots seldom or never produce such a dense mass of fine fibrils as do those of the grasses, but the underground stocks if less finely branched penetrate deeply or spread widely. Their fibres, which are usually thicker than those of grasses, are very generally provided with little tubercles or nodules. Microscopic examination of the tubercles in *Trifolium repens* has shown us that they consist of an epidermal covering, investing two or three layers of cortical cells, within which is a circle of very minute fibro-vascular bundles with delicate spiral vessels. The central portion within the vessels is occupied by a large mass of cellular tissue, the innermost cells of which are larger than the outer polygonal, and often containing "crystalloid" contents, perhaps of aleurone or of some albuminoid substance. The fibro-vascular bundles are directly continuous with the vascular cylinder of the root fibre. There seems, then, no doubt, that these nodules are modified root fibres.* When fully formed no root-cap is visible, nor is this surprising, as their function seems to be not to extend the growth of the root but to furnish a magazine of nutritive matter. For the same reasons, probably, all the specimens that we have examined have been entirely destitute of root-hairs.

[Owing to the peculiar conformation of the flowers, the intervention of insects becomes almost absolutely essential to the fertilisation of these plants, as illustrated by Mr. DARWIN'S remarks on the interdependence of the red-clover, humble-bees, field-mice, and cats.]

Although the occurrence and amount of leguminous species materially affect the quality of the mixed herbage of meadow land, and are very dependent on the manurial conditions supplied, the proportion they contribute to the total produce is comparatively small, even when they are considered to be well represented. Indeed, if we were to attempt to represent the predominance of the leguminous species in the *total mixed herbage*, it happens that the most prominent of them would only once be first in predominance among the total species on the plot. It is, therefore, necessary in the tables of predominance to show those which take the first, the second, or the third place among the total leguminous, and not among the total mixed herbage of the plot. It is essential to bear this in mind in looking at the tables, otherwise the frequency with which one or other of the four leguminous species occurring in any material quantity on the plots appear as first, second, or third, would be quite misleading. The columns showing when the respective plants contributed 5 per cent. or over to the total produce, clearly show, by the very few entries, and the many blanks, the relatively small proportion of such herbage.

* See WORONIN, Ann. Sc. Nat. 5me. sér., vol. 7, p. 84, tab. 6, who shows that these tubercles are associated with the presence of Bacteria, but in our experience they may occur without them, at least it is only occasionally that we have been able to detect them. The subject of root tubers has attracted the more attention of late from the presence of somewhat similar nodules on the roots of vines affected with Phylloxera, but the resemblance to the leguminous tubercles is merely superficial. Other similar swellings have been attributed to the presence of a myxomycetous fungus.

Trifolium repens.

The common white clover has a long, deeply penetrating, tap-root, giving off numerous rather thick, wiry, flexuous branches, studded with little tubercles, and descending obliquely into the soil. The stock gives off numerous, slender branches, creeping on the ground over and between the leaves and stems of neighbouring plants, and producing abundance of fine fibrous adventitious roots. The leaves are small, consisting each of three rounded flat leaflets, which in the young state are folded in halves, and so occupy comparatively little space. It flowers from May to October, but is rarely seen in fruit on the plots, its propagation being mainly secured by means of the creeping branches. The plant, moreover, is peculiarly subject in some seasons to have its floral organs more or less completely replaced by leaves.

The common white clover is one of those plants which is particularly liable to make its appearance on reclaimed land from estuaries and the like; also on land over which fire has passed, and often on new-made ground, seeming thus to have special capacities for availing itself of the conditions so afforded.

The structural endowments specially favourable to its diffusion are its hardiness and power of adaptation, as shown by its wide geographical distribution, its two-fold root power—the long tap root enabling it to derive moisture and nourishment from the lower layers of the soil, and thus to be comparatively independent of drought, while the abundant adventitious roots emitted from the creeping branches enable it to avail itself largely also of the surface-soil supplies. The trailing branches and closely folded young leaves also give the plant the advantage of making its way in between its neighbours, and so enabling it to avail itself readily of any vacant space. Its hard resisting seed-coat enables the seed to lie in the ground for long periods until circumstances become favourable for germination.

The following table shows the relative degree of predominance of this plant.

TABLE LI.—Relative predominance of *Trifolium repens*.

		Trifolium repens							
		Was First, Second, or Third, among the total Leguminosæ, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	2	2	2	2	..	..	..	..
	2	2	..	2	..	..	..	..	..
	4–1	2	..	3	..	..	..	..	..
	4–2	2	2	..	2	..	..	..	..
	5	..	2	3	..	..	..	..	..
	6	3	2	..	..	..	..	..	..
	7	3	..	2	..	..	..	..	..
	8	3	..	..	..	..	..	..	..
	9	2	2	..	..	..	..	..	..
	10	2	..	1	..	..	..	..	..
	11–1	..	..	1	..	..	..	..	..
	13	2	2	2	..	..	..	..	..
	14	2	2	..	..	..	..	..	..
	15	2	2	1	3	..	..	..	..
	16	2	3	3	..	..	..	..	..
	17	2	1	3	3	..	..	..	..
	18	..	..	3	..	..	..	..	..
	19	..	..	..	2	..	..	..	..
	20	..	..	3	2	..	..	..	..
Total	First	0	1	3	0	0	0	0	0
	Second	11	8	4	4				
	Third	3	1	6	2				

On only two plots, those receiving mineral manure including potass, did this plant ever contribute more than 2 per cent. of the total produce, and the highest amount was 3·08 per cent. It is shown to be first in quantity among the Leguminosæ on one plot in 1867, and on three in 1872. It was second on 11 plots in 1862, on eight in 1867, on four in 1872, and on four in 1877; and it was third on three plots in 1862, on one in 1867, on six in 1872, and on two in 1877. Yet this plant on no plot in either year yielded 5 per cent. of the total produce. Indeed, the cases in which it showed prominence among its allies were only those in which the total Leguminosæ were in comparatively insignificant amount; and where it was in the largest actual quantity it was so overpowered by other leguminous species that it did not attain to any relative predominance. It occurred in the smallest actual amount where ammonia-salts were used; it was rather more favoured on the nitrate of soda plots; but it gave a higher percentage without manure, and the highest of all with purely mineral manures containing potass.

On the whole it would appear that this plant is diminishing on the greater number of the plots; but there are several circumstances to be taken into account. For instance, it is certain that neither the percentage tables, nor those showing the weight

of the produce yielded by this plant, give a wholly correct idea of the real quantities present. Its procumbent habit renders it liable to be concealed by taller-growing plants and overlooked, and may also prevent it from being reached by the scythe. Hence it may readily exist to some extent beyond what the records show. In this manner, in a measure, as SINCLAIR long ago pointed out ('Hort. Gram. Woburn.,' p. 223), may be accounted for those statements of the sudden appearance of the white clover on land which has been cleared or broken up, where it had not previously been noticed. Some instances of this have been observed at Rothamsted. Its great variability and power of adaptation to different circumstances also conduce to this result; but probably the result is due largely to the nature of the seed, which is so constructed as to lie uninjured in the soil for a long period of time, until the conditions are favourable for germination, when it would spread rapidly, by means of its offshoots, and quickly occupy vacant spaces.

Trifolium pratense.

The ordinary red clover of grass land is a tufted, very deeply-rooting perennial, (sometimes annual) with numerous long, thick tap-shaped roots, more or less branched, and with rather thick wavy fibres, provided with nodules, but almost destitute of root-hairs.* The stock is divided into numerous short, stout, spreading branches, with no true runners, but the central portion of the stock or crown ultimately dies, and the branches then form independent plants. Its growth begins early in spring; it flowers and ripens seed both in the first and second crops, though seedlings are rarely observed on the plots.

The structural characteristics favourable to the growth of this plant are: its powerful deep-rooting habit, enabling it to get food from considerable depths, and thereby also preserving it from the effects of drought; its lateral roots availing themselves of the nutriment in the upper layers of the soil, while the fleshy substance of the main roots acts as a storehouse; its downy leaflets serving as a protection from frost, or excessive radiation, and the way in which they are folded in the young state enabling them to insinuate themselves between its competitors; lastly, its extensive distribution in the northern hemisphere of the Old World shows that it bears low temperatures, but in spite of these properties it is gradually declining on the experimental plots.

The following table shows the relative degree of predominance of this plant.

* The characters of the roots of this plant under treatment with various manures, during two seasons at Chiswick, are noted in the Journal of the Royal Horticultural Society, vol. iii., 1870, pp. 49 and 140.

TABLE LII.—Relative predominance of *Trifolium pratense*.

	Trifolium pratense							
	Was First, Second, or Third, among the total Leguminosæ, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
	1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots 1	2	3	2	..	..	..	..	..
2	3	2	3	2	..	..	..	..
3	1	2	2	3	..	..	..	..
4–1	1	3	..	..	..	..	..	..
4–2	2	..	2	..	..	..	..	..
5	2	2	..	..	..	..	..	..
6	2	2	3	2	..	..	..	..
7	2	2	3	2	6·84	..	..	..
8	2	2	3	3	7·71	..	..	..
9	..	..	..	3	..	..	..	..
10	..	..	..	1	..	..	..	..
12	1	2	3	3	..	..	..	..
13	3	..	2	..	..	..	..	..
14	2	2	2	..	..	..	..	..
15	1	3	2	2	..	..	..	..
16	1	1	2	2	..	..	..	..
17	1	2	2	2	..	..	..	..
18	—	1	..	3	—	..	..	..
19	—	—	1	3	—	—	..	..
20	—	—	2	..	—	—	..	..
Total First	6	2	1	1	2	0	0	0
Total Second.	7	9	9	6				
Total Third	2	3	5	6				

This plant was first among four leguminous species on six plots in 1862, on two in 1867, and on one only in 1872 and 1877. It was second on seven plots in 1862, on nine in 1867, on nine in 1872, and on six in 1877, and it was third on two in 182, on three in 1867, on five in 1872, and on six in 1877. But it contributed as much as 5 per cent. to the total produce on only two plots, with purely mineral manure, and on these only in the first of the four separation-years.

It is practically absent from the samples taken from the plots where ammonia-salts are applied, whether these be used alone or in conjunction with mineral manures. It has gone down, but in a less degree, where nitrate of soda has been used. It has also gone down on the plots most favourable to Leguminosæ in general, and where it increased considerably in the early years—namely, those where mixed mineral manure, including potass, was employed. Finally, it has maintained a more uniform position on the unmanured plots, where there is no luxuriance of any species, than anywhere else; but here, in the later years, it has only contributed about 2 per cent. of the total produce. It has, in fact, not maintained even moderate prominence where there was any luxuriance of the grasses; and where the conditions were more favourable for the

Leguminosæ collectively, *Trifolium pratense*, like *T. repens*, has given place to other plants of the same family. It has, however, sustained the competition much better than *T. repens*.

There are other species of this genus which occur on the plots, but only in insignificant proportions, viz.:—

Trifolium minus.—This plant has only once been found in the samples, and then only in very insignificant amount.

Trifolium procumbens has twice been found in the samples, but, like *T. minus*, in most insignificant quantity.

Both *T. minus* and *T. procumbens* are, however, frequent in the immediate neighbourhood; and it is probable, from the appearance of the plots during growth, as well as from the creeping habit of the plants, that the samples do not adequately represent the amount of these plants on the plots, though in any case it must be very small, such plants having little or no capabilities of maintaining themselves amid their more powerful rivals.

Lotus corniculatus.

The root or subterranean stock of this robust perennial is tap-shaped, stout, fleshy, whitish, descending deeply into the sub-soil, its main branches are slender, horizontal, with numerous nodules, the lower branches descending, destitute, or nearly so, of nodules. The above-ground stem forms tufts of wiry decumbent or erect branches, bearing leaves of the same general shape as those of the clovers, but smaller. It flowers, as a rule, too late to perfect its seed before mowing. It is very hardy, bears drought well, is not very particular as to soil, but is stated to be variable on different soils, &c. At Rothamsted the variety which occurs is that called *vulgaris* in HOOKER's 'Student's Flora,' and it is pretty constant in its characteristics.

The conditions propitious to it are: its powerful root-stock, with extensive storage of nutritive matter, deep range, and power of availing itself of the food and moisture in the lower layers of the soil; the fact that the seeds are rarely produced before the first cutting, thus obviating exhaustion, and tending to prolong the life of the individual; its hardy constitution, as shown by its wide geographical distribution, its relative indifference to the nature of the soil, climate, &c.

For its predominance see the subjoined table.

TABLE LIII.—Relative predominance of *Lotus corniculatus*.

		Lotus corniculatus							
		Was First, Second, or Third, among the total Leguminosæ, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	2	..	3	..	3	..	..	..	..
	3	2	1	1	1	..	..	5·94	..
	4–1	3	2	2	2	..	..	..	..
	5	1	1	1	1	..	..	..	..
	6	3	1	2	3	..	..	..	..
	7	..	3	..	3	..	..	..	..
	8	..	3	2	2	..	..	..	..
	10	..	..	..	1	..	..	..	..
	11–1	..	1	..	..	..	..	..	..
	12	3	1	1	1	..	..	5·16	..
	13	..	..	2	..	..	..	..	..
	15	3	1	2	3	..	..	..	..
	16	..	..	..	3	..	..	..	..
	17	2	3	1	1	..	..	..	..
	18	—	3	1	2	—	..	..	..
	19	—	—	2	..	—	—	..	..
	20	—	—	1	3	—	—	..	..
Total	First	1	6	6	5	0	0	2	0
	Second	2	1	6	3				
	Third	4	5	0	6				

Lotus corniculatus was first amongst its few allies on one plot in 1862, on six in 1867, on six in 1872, and on five in 1877. It was second on two plots in 1862, on one in 1867, on six in 1872, and on three in 1877. It was third on four plots in 1862, on five in 1867, on none in 1872, but on six in 1877. Notwithstanding this considerable predominance among Leguminosæ, it only yielded more than 5 per cent. of the total mixed herbage on the two unmanured plots, and there only once, viz.: in the third separation-year. Like the other leguminous species, it has gone down in a very marked manner on all the plots where ammonia-salts were used; but it has done so less where these were used alone, and where only poor surface-rooting grasses were stimulated against it, and again on plot 18, where only a small quantity of ammonia-salts, with a complete mineral manure, was employed. It has been less reduced on the plots only moderately manured with nitrate of soda. On the unmanured plots alone has it shown any marked increase; but with superphosphate of lime alone, and with the mixed mineral manure without potass, it has also shown a tendency to increase rather than to diminish. Where the mixed mineral manure, including potass, is applied, it is the more surface-rooting *Lathyrus pratensis* that prominently represents leguminous growth; and it is only where there is no luxuriance of grasses, or of more

surface-feeding Leguminosæ, that the *Lotus corniculatus*, with its deeper roots, hardy habit, and comparative independence of surface-food and surface-moisture, appears to be able to maintain or to improve its position.

Lathyrus pratensis.

This is a perennial plant with a root-stock greatly differing in character from that of the *Lotus corniculatus*, being very long, slender, wiry, black in colour, creeping, or in some cases descending vertically to considerable depths, slightly branched, but never forming thick fleshy branches like the *Lotus*. On the other hand, it produces adventitious buds, and roots much more freely. By these comparatively superficial roots it is enabled to avail itself more fully than the *Lotus* does of the food in the surface soil. The stems are slender, weak, angled or flattish, trailing, or supporting themselves by means of the leaf-tendrils. It begins to grow late in the spring, and flowers abundantly, but it does not as a rule ripen its seeds on the plots before cutting.

The characteristics which favour its growth are its hardiness and robust constitution, its creeping root-stock, and its tendrils which enable it to avail itself, at little cost to itself, of the stems of its neighbours, and it may be to strangle them. Its duration is also probably increased by the circumstance that it so rarely perfects seeds on the plots. The peculiar manner in which the leaves are folded flat in the bud, so as to occupy little space and enable the plant to push its way through and between its competitors, is also noteworthy.

The following table shows the relative degree of prominence of this plant.

TABLE LIV.—Relative predominance of *Lathyrus pratensis*.

	Lathyrus pratensis							
	Was First, Second, or Third, among the total Leguminosæ, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
	1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots 1	1	1	1	1	..	..	..	..
2	1	1	1	1	..	..	..	5·25
3	3	3	3	2	..	..	..	..
4–1	..	1	1	1	..	..	..	..
4–2	1	1	1	1	..	..	..	..
5	3	2	2	2	..	..	..	..
6	1	..	1	1	..	..	..	6·56
7	1	1	1	1	13·51	6·78	36·68	12·11
8	1	1	1	1	8·76	6·82	..	..
9	1	1	1	2	..	..	..	..
10	1	1	1	..	..	..	..	..
11–1	1	..	..	..	..	..	..	..
12	2	3	2	2	..	..	..	..
13	1	1	1	..	..	..	..	..
14	1	1	1	1	..	..	..	..
15	..	3	..	1	..	..	..	..
16	3	2	1	1	..	..	6·68	9·22
17	..	..	..	3	..	..	..	..
18	—	2	2	1	—	..	..	..
19	—	—	3	1	—	—	..	6·92
20	—	—	..	1	—	—	..	..
Total First	11	10	12	13	2	2	2	5
Total Second	1	3	3	4				
Total Third	3	3	2	1				

Among the four leguminous species of any distinct prominence at all, this plant takes the first place in the greatest number of instances. It was the first of the four on 11 plots in 1862, on 10 in 1867, on 12 in 1872, and on 13 in 1877. It was second on only one plot in 1862, on three in 1867 and 1872, and on four in 1877. It was third on three plots in 1862 and 1867, on two in 1872, and on one only in 1877. It, however, yielded more than 5 per cent. of the total produce on only two plots in 1862, two in 1867, two in 1872, but on five in 1877. Like its three allies it has almost disappeared on most of the ammonia plots; but has even increased where the smaller quantity of nitrate of soda was employed, especially when in conjunction with mineral manure containing potass. Without manure, although the actual quantity is small, it has increased rather than diminished; but in a considerably less degree than the *Lotus*.

The most striking point in the development of *Lathyrus* on the experimental plots is its very great increase where mineral manure, including potass, is used, without nitrogenous manure. The table shows that on plot 6, where ammonia salts had been applied during the first 13 years, but a mixed mineral manure, including potass (with-

out ammonia), in 1869, and each year since, *Lathyrus* did not contribute 5 per cent. to the produce in either 1862, 1867, or 1872, but that it did so in 1877, that is some years after the change. The plant yielded more than 5 per cent. to the produce in each separation-year on plot 7, where the mixed mineral manure, including potass, was applied alone every year. And it did so in 1862 and 1867, but not afterwards, on plot 8, to which the same mixed mineral manure, including potass (in considerable excess), was applied for six years, to 1861 inclusive, but without potass in 1862 and afterwards.

The actual percentage of *Lathyrus* in the total herbage was increased from 0·23 in the first, to 6·56 in the last separation-year on plot 6, where the ammonia-salts were applied in the earlier years, and the potass manure in the later. It diminished from 8·76 to 2·37 per cent. on plot 8, which received potass during the earlier, but not during the later years; and on plot 7, where the mineral manure including potass was applied every year, *Lathyrus* contributed 13·51 per cent. in the warm moist season of 1862, 6·78 per cent. in the cold and changeable season of 1867, 36·68 per cent. in the variable season of 1872, and 12·11 per cent. in the tardy spring of 1877. It also increased up to 9·22 per cent. in 1877 on plot 16, where the smaller quantity of nitrate with the mineral manure, including potass, was every year applied. It has likewise increased in a very remarkable degree, in recent years, on plot 15, where nitrate of soda alone was applied up to 1875 inclusive, but the mixed mineral manure, including potass (without nitrate), each year since. It is obvious that potass manure has remarkably increased the development of this species, whilst it has not done so in the case of either of its three allies.

Somewhat detailed reference has already been made to this result in the section relating to plot 7 (Part I., p. 307, *et seq.*); and the subject will come up again when discussing the botany, and again when discussing the chemistry, of that plot. But it may here be remarked that, of the four leguminous species which have been considered, the *Lathyrus* feeds by its adventitious roots very much more than the rest in the surface-soil; that the supplied potass descends comparatively little into the sub-soil; and that the nitrogen of the surface-soil where this leguminous plant has so remarkably developed, has diminished in a greater degree than on any other plot. It would appear that under the influence of the liberal potass supply, the plant has been enabled to obtain the large amount of nitrogen it requires in a greater degree from the accumulated stores within the surface-soil.

It seems probable, from the foregoing data, that some of the fluctuations in the amount of produce yielded in different seasons by this plant may be explained by its peculiar habit of growth. Its underground development, either of root or stock, is relatively small, as compared either with that of most of the grasses or with that of *Lotus* and the *Clovers*. On the other hand, its above-ground growth, its creeping stems and erect branches, insinuating themselves between their competitors, and clinging to them by means of their tendrils, &c., constitute differences which may go

far to explain the fluctuations above recorded. The great increase on those plots where this plant predominated was in the year 1872, a year when the spring temperature was above average but the rainfall below it—conditions which may have acted partly by discouraging its competitors, and partly by directly favouring its own growth.

Three other species of the leguminous family, *Ononis arvensis*, *Vicia cracca*, and *Vicia sepium*, have been found on the plots; but only one of them, the *Ononis arvensis*, has been so far developed as to come into the samples, then only on one plot—that with superphosphate of lime alone, and in quite insignificant amount.

The Miscellaneous Plants.

The plants included under this heading comprise, in all, 59 species (exclusive of Fungi), distributed through 44 genera and 20 families. A detailed list of these Orders, genera, and species is given at pp. 1210–11. Representatives of some of these families form a conspicuous portion of the herbage on some of the plots, while on others they are not found at all. The relative proportions also in which they occur are exceedingly different.

The plants which have occurred at some time in the samples from all the plots, or which have been observed during growth on all, are *Ranunculus acris*, *Conopodium denudatum*, *Achillea Millefolium*, *Rumex Acetosa*, *Luzula campestris*, and *Hypnum squarrosum*. The following have occurred on a large number of the plots: *Ranunculus bulbosus*, *R. repens*, *R. Ficaria*, *Stellaria graminea*, *Cerastium triviale*, *Pimpinella Saxifraga*, *Heracleum Sphondylium*, *Galium verum*, *Scabiosa arvensis*, *Centaurea nigra*, *Taraxacum officinale*, *Plantago lanceolata*, *Veronica Chamædrys*, and *Carex præcox*. The plants which have only been observed on a small number of plots are: *Ranunculus auricomus*, *Cardamine pratensis*, *Stellaria Holostea*, *Hypericum perforatum*, *Potentilla reptans*, *P. Fragariastrum*, *Alchemilla vulgaris*, *Agrimonia Eupatoria*, *Poterium Sanguisorba*, *Spiræa Ulmaria*, *Anthriscus sylvestris*, *Daucus Carota*, *Galium Aparine*, *Carduus arvensis*, *Bellis perennis*, *Chrysanthemum Leucanthemum*, *Senecio erucifolius*, *Hypochæris radicata*, *Tragopogon pratensis*, *Leontodon hispidus*, *L. autumnalis*, *Sonchus oleraceus*, *Hieracium Pilosella*, *Plantago media*, *Veronica serpyllifolia*, *V. officinalis*, *Thymus Serpyllum*, *Prunella vulgaris*, *Ajuga reptans*, *Primula veris*, *Rumex crispus*, *R. obtusifolius*, *Orchis Morio*, *Scilla nutans*, *Fritillaria Meleagris*, *Ornithogalum umbellatum*, and *Ophioglossum vulgatum*.

The occurrence of certain plants on all or on a majority of the plots seems to indicate that the plants in question are in a considerable degree independent of manurial influence, or are able to adapt themselves to circumstances better than others—a power arising probably from diverse characteristics as to habit and internal structure (see *ante* p. 1222). The proportions, however, in which particular plants are found depend very greatly on manurial agency and association.

In the list given at pp. 1210–11 the plants are arranged in botanical order; but in dis-

cussing the constituents of the miscellaneous herbage in this place, the plan followed is, to mention first those which have been respectively first, second or third in order of predominance among their associates, or those which have contributed not less than 5 per cent. of the total produce. Other plants which are not so well represented, either in relative predominance or in percentage, and concerning which it is not necessary to speak at so much length, are treated of subsequently; while those Orders in which none of the members are represented in the degree above-mentioned are briefly alluded to at the end of the section.

Ranunculaceæ.

The species of this Order found on the plots are few in number. Three of them, *R. acris*, *R. bulbosus*, and *R. repens*, are met with in greater or less abundance on all the plots. *R. Ficaria* occurs on 11, but it does not figure in the samples taken in the separation-years; *R. auricomus*, also, has only been found on two plots, and in only one sample (that from plot 16 in 1877), although it is not uncommon in the adjacent woods and shrubberies.

Ranunculus bulbosus and *R. repens*.

It is unfortunate that, owing to the difficulty of determining to which of these two species fragments of leaves and stems such as occur in the samples belong, the two plants are taken together in the tables showing the percentage and the weight of the several constituents of the herbage. This is the more to be regretted as the habit of the two species is so different.

R. bulbosus is an erect perennial, with a somewhat globose root-stock, destitute of runners, but reproduced by the formation of a new bulb-like bud at the top of the old one. The root-fibres are thick, whitish, unbranched, and descend vertically. The hairs on the stem and foliage are usually longer and coarser than in *R. repens*. It flowers and produces seed abundantly.

R. repens has, as the name implies, creeping, prostrate stems, which give off runners or creeping shoots, which root at the nodes, where they form fresh plants, and thus enable the plant to reproduce itself freely without seeding, which rather rarely happens. The roots are similar to those of *R. bulbosus*, but more slender.

The following table illustrates the predominance of the two species collectively.

TABLE LV.—Relative predominance of *Ranunculus bulbosus* and *R. repens*.

		Ranunculus bulbosus and *R. repens*							
		Were First, Second, or Third, among the total Miscellaneous, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	2	..	..	3	..	..	..	..
	2	2	..	3	2	..	..	..	..
	3	2	..	2	1	..	..	..	..
	4–1	1	..	2	1	5·87	..	..	5·84
	4–2	2	..	..	..	..	..	..	..
	8	3	..	..	..	..	..	..	..
	12	3	..	..	1	..	..	..	6·45
	14	3	..	..	..	..	..	..	..
	16	2	..	..	..	..	..	..	..
	18	—	2	2	3	—	5·73	..	..
	19	—	—	1	..	—	—	..	..
	20	—	—	1	1	—	—	..	..
Total	First	1	0	2	4	1	1	0	2
	Second	5	1	3	1				
	Third	3	0	1	2				

In 1862 *R. bulbosus* and *R. repens*, taken together, were once first, five times second, and three times third, among the total miscellaneous herbage; in 1867 they were not first at all, only once second, and not third at all; in 1872 they were twice first, but only on the two plots brought under experiment for the first time in that year, but they were three times second and once third; in 1877 they were four times first, once second, and twice third.

Notwithstanding this seeming prominence, they together only yielded a very little over 5 per cent. of the total produce on one plot in 1862, on one in 1867, on none in 1872, and on two plots in 1877. The only plots on which they supplied from 5 to 6 per cent. were three of small total produce, viz.: 4–1 (superphosphate alone), in 1862 and in 1867, 12 (unmanured), and 18 (minerals and nitrogen contained in 1 ton of hay).

The plots on which these plants came first, second, or third among the miscellaneous herbage, but on which they did not contribute 5 per cent. to the total produce, were mostly characterised by meagre luxuriance; the exceptions being plot 16 (mineral manure and the smaller quantity of nitrate of soda), plot 14 (mineral manure and the larger quantity of nitrate of soda), and the two newer nitrate and mineral plots, 19 and 20. They were absent from, or present in very small quantities, in the samples from the plots treated with ammonia-salts in conjunction with mineral manure where the gramineous herbage was luxuriant. They were, however, it is seen, more abundant on the nitrate plots.

It may be observed that of the two species *R. bulbosus* was by far the most frequent and prominent; but *R. repens* is in relatively larger proportion on plot 1 (ammonia-

salts with, or after farmyard manure), and on plot 5 (ammonia-salts alone). It is obvious, therefore, that, on the whole, these plants have only retained a comparatively prominent place where the growth of those associated with them has been relatively small.

Ranunculus acris.—This is a tall-growing species, with a thick root-stock, from which proceed a number of white, rather fleshy, root-fibres, branching obliquely, and horizontally, destitute of root-hairs, and not descending very deeply. It is destitute alike of the thickened stem of *R. bulbosus* and of the creeping shoots of *R. repens*, and has, apart from its constitutional or physiological characteristics, no very obvious structural endowments to account for its frequency of occurrence, unless it be its tall stature and abundant production of seed, both in the first and second crops. It did not attain a first, second, or third position among the miscellaneous herbage on any plot; nor did it in any case yield 5 per cent. of the total produce. It was absent, or nearly so, wherever ammonia-salts with mineral manures were applied, and where, accordingly, there was considerable luxuriance, especially of certain grasses. Thus on plot 4–1 (superphosphate only) there is commonly in spring a large quantity of this plant, while on plot 4–2, to which ammonia-salts as well as superphosphate are applied, there is little or none. It was in small, but nevertheless in larger quantity on the unmanured, and on the purely mineral manured plots, on which the herbage generally was not luxuriant. It was considerably more prominent on the nitrate of soda plots, and was especially so where the smaller quantity of nitrate was used without mineral manure, and again on the plot where the larger quantity of nitrate of soda had been applied alone up to 1875, and mixed mineral manure afterwards. On the former it reached 2·95, and on the latter 3·74 per cent. of the total produce in the fourth separation year 1877.

Ranunculus Ficaria.—This, the lesser Celandine, is a low-growing species, producing a number of fleshy root-like tubers, by means of which the plant is propagated, as it is also by means of numerous sub-globose thickened buds, formed under certain circumstances in the axils of the leaves, whence they detach themselves and, falling to the ground, grow into distinct plants. It flowers so early (April) that it is rarely noticed in the summer months, and its leaves form no distinguishable part of the samples, as the foliage is withered before the hay is cut; or, from the leaves being so near the ground, it is passed over by the scythe. It has been noticed on 11 plots, and in largest quantity on plot 16 (nitrate of soda and minerals).

Ranunculus auricomus has the general habit of *R. acris*, but is not so tall and is much more glabrous. Its flowers are rarely, if ever, found in a perfect condition, the petals being more or less defective in size or number. It is conjectured that this plant does not stand in the same need for insects to insure its fertilization, as do the other more conspicuous flowered species. It has been seen on plot 16, and on no other, and, like the Celandine, it withers before the crop is cut, and thus forms no part of the samples.

The structural characters of the foregoing five species of *Ranunculus* (all more or less acrid) are thus seen to be very different, so far at least as their vegetative organs are concerned. Their floral structure is much more uniform. The peculiar structural endowments of *R. bulbosus*, *repens*, and *Ficaria* give them great advantages, while the others are able specially to assert themselves when the competition with associated plants is not severe.

Caryophyllaceæ.

This Order is only represented by three species, viz.: *Stellaria graminea*, *S. Holostea*, and *Cerastium triviale*. *S. graminea* and *C. triviale* occur on a large number of plots, but *S. Holostea* has only once been found in the samples, and neither *S. graminea* nor *S. Holostea* has ever been first, second, or third in order of predominance; nor has either of them, on any occasion, yielded as much as 5 per cent. of the produce. All are weak-stemmed plants, with relatively small true roots. *Cerastium triviale*, however, has a great tendency, when placed under suitable conditions, to form both roots and shoots at the nodes, so that, under such circumstances, it increases rapidly.

Cerastium triviale.

This perennial weed forms intricate masses of slender shallow roots, and numerous prostrate slender leafy branches, which produce roots and shoots at the nodes. Root-hairs are abundant. It flowers early, and ripens seeds on a great number of the plots.

The circumstances propitious to its growth are its hardiness, close habit, which enables it to insinuate itself between the branches and leaves of other plants, and to occupy any vacant ground, and its early and free seeding property, by reason of which the seeds may get dispersed by the mowers and haymakers. The following table shows that, although this plant occurs so generally on the plots, it very seldom attains a really prominent position as to amount of produce.

Table LVI.—Relative predominance of *Cerastium triviale*.

		Cerastium triviale							
		Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	12	..	..	3	..	..	..	..	..
	15	..	3	1	..	..	..	9·26	..
	17	..	..	2	..	..	..	..	..
Total	First	0	0	1	0	0	0	1	0
	Second	0	0	1	0				
	Third	0	1	1	0				

Thus, *Cerastium triviale* was only once first among the miscellaneous plants, viz.: in 1872 on plot 15 (with the larger quantity of nitrate of soda alone), on which it had previously been third in 1867. In 1872, the third separation-year, it was also second on plot 17 (with the smaller quantity of nitrate alone). In the same year it was third on one of the unmanured plots, 12. On only one occasion, however, has it contributed more than 5 per cent. of the total produce, and this was in 1872, on the plot with the larger amount of nitrate of soda alone, when it gave 9·26 per cent.

This plant was, therefore, most favoured under the influence of nitrate of soda alone. It was all but absent from the ammonia plots, and was very sparingly represented on the mineral manure plots. Next to the nitrate plots it succeeded best without any manure at all. It is obvious that it cannot sustain itself in competition where there is any general luxuriant growth among its associates; the only apparent exception being under the conditions of partial luxuriance induced by nitrate of soda alone. The explanation of this may be that it is specially fitted to take advantage of the direct supply in the upper layers of the soil.

Umbelliferæ.

This is a large and well marked Order, morphologically speaking, but its chemical products vary greatly. The species are almost without exception herbaceous perennials, and they occur in very various localities in most regions of the globe, except the intertropical. The plants of this family represented on the plots are: *Conopodium denudatum*, found on all the plots in each separation-year; *Pimpinella Saxifraga*, found on most of the plots; *Heracleum Sphondylium* on a large number, especially in the earlier years; *Anthriscus sylvestris* on a few, and *Daucus Carota* on one.

Conopodium denudatum.

This plant is a perennial, with a blackish sub-globose tuberous root-stock (whence the name "earth nut") at a slight depth below the surface, and studded with protuberances or buds, from which proceed slender, erect stems, 1 to 3 feet high, and minute thread-like roots, which do not penetrate very deeply. The leaves are ternately divided, the segments again finely cut.

It flowers in May, ripens and sheds seeds previous to the first mowing, on which account its weight in the samples is less than it otherwise would be in proportion to the number of plants on the plots.

The structural features favourable to the plant are its tuberous root-stock, which secures it from injury from drought or frost, and ensures a supply of buds and fresh shoots. These tubers are, however, sought out by wood pigeons and other creatures. Its diffusion is also favoured by the abundance of seed which it produces. The manner

in which its thin stems and folded leaves push themselves up between other plants, also confers an advantage on this plant.

The following table shows its relative degree of prominence.

TABLE LVII.—Relative predominance of *Conopodium denudatum*.

		Conopodium denudatum							
		Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent., and over, to the total mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	3	3	..	..	..	..	..	..
	2	3	3	..	..	..	..	..	..
	3	..	..	3	..	..	..	..	..
	4-2	..	2	..	..	..	..	..	..
	5	3	2	..	3	..	5·74	..	..
	6	..	2	3	..	..	7·87	..	..
	7	2	1	3	2	..	9·22	..	..
	8	2	2	..	..	..	6·84	..	..
	9	2	2	2	2	..	9·35	..	..
	10	2	2	..	..	..	..	..	..
	11-1	2	2	2	3	..	..	..	..
	11-2	2	2	2	3	..	..	..	..
	12	..	2	..	2	..	5·42	..	..
	13	3	1	2	2	..	8·04	..	..
	14	2	1	2	..	..	..	..	..
	16	3	2	1	..	..	..	..	..
	18	—	3	3	2	—	..	..	..
	19	—	—	2	1	—	—	..	..
	20	—	—	2	2	—	—	..	..
Total	First	0	3	1	1	0	7	0	0
	Second	7	10	7	6				
	Third	5	3	4	3				

It is seen from this table that *Conopodium denudatum*, perhaps owing partly to the relative delicacy of its foliage, and partly to its early ripening and loss of seed before cutting, very seldom came first in predominance by weight among the total miscellaneous herbage. In 1862 it was second on seven, and third on five plots; in 1867 it was three times first, ten times second, and three times third; in 1872 it was once first, seven times second, and four times third; and in 1877 it was once first, six times second, and three times third. Thus, although it was very seldom first, it was very frequently second, and rather frequently third.

Yet only in the second separation-year, when the cold spring checked the grasses, did the amount ever reach 5 per cent. of the total produce, but then it did so on seven plots. The only plots upon which it was neither first, second, nor third, nor yielded 5 per cent. to the produce in either separation-year, were plot 4–1 (superphosphate of lime alone), plot 15 (with the larger quantity of nitrate of soda alone), and plot 17 (with the smaller quantity of nitrate of soda alone).

In the second separation-year, 1867, when it reached its highest amounts, it was most productive on the two plots 9 and 13 highly dressed with both mineral manure and ammonia-salts, and on plot 7, with the mixed mineral manure, including potash, but without ammonia. It is obvious that this plant can, probably by reason of its tuber, and its thin stems which are not overpowered by the grasses, sustain the competition of free-growing grasses, even when these latter are stimulated by ammonia-salts in conjunction with mineral manures; but a liberal supply of the latter would seem to be essential to its luxuriance. It is apparently much less favoured by nitrate of soda than by ammonia-salts. The table shows that it occurred in very much less amount in the third and fourth separation-years; although in some seasons it has been very conspicuous on many plots. During the three years (1878, 1879, 1880) it was estimated to be either first, second, or third in order on the unmanured plots, and on those treated with ammonia-salts. On plot 9 (minerals and ammonia) it has been conspicuous and abundant, but with the minerals and the double quantity of ammonia (plot 11) it has not thriven; and during the three years above-mentioned it has occurred very rarely on this plot—but abundantly on plot 20, with the nitrate of potass and superphosphate.

With regard to the great development of this plant in 1867, it may be observed that it corresponded nearly with that of *Rumex Acetosa* in the same season. Perhaps the relatively low spring rainfall and temperature of that season may have discouraged the growth of the grasses, and thereby allowed of the superior growth of *Conopodium*, *Rumex*, and other miscellaneous plants.

Pimpinella Saxifraga.

This has a short, stout stock, rather slender, erect stems, and pinnately divided broad leaves. It was found in the samples from almost all the plots, excepting those liberally manured with ammonia-salts, from which it was frequently absent. It was also in very small amount in the samples from the nitrate plots; and it was the most prominent on the unmanured plots, and on those receiving an only partial mineral manure. Excepting that it was more prominent in the second than in either of the other separation-years, it may be said to have gone down, even on the plots the most favourable to it; and it has done so more markedly on the unmanured plots, than on the one treated with superphosphate of lime alone. It is obvious that this Umbellifer is not able to hold its own under the influence of nitrogenous manures, whether alone or in conjunction with mineral manures, that is under conditions which favour the grasses, nor when mineral manures are used alone, in which case the luxuriance of Leguminosæ, and other plants, is promoted.

Heracleum Sphondylium.

This is a tall, coarse-growing plant, with very large, thick, fleshy, deeply-penetrating root-fibres, and broad rough foliage. It is a biennial, and occurs generally in isolated

examples, not in groups. It seeds freely, and if the seedlings spring up upon any vacant patches, they speedily avail themselves of the space to the exclusion of other species.

Owing to the plant generally occurring as isolated specimens it was frequently noted as existing on the plots although it was not included in the samples. It is obvious that, from the character of the plant, there must be some uncertainty as to the amount coming into the sample being a true representation of its proportion in the total herbage of the plot. From the notes taken on the ground it would appear probable that there was a greater number of plants on some of the plots, where there was comparatively little general luxuriance, but it was only where there was liberal nitrogenous and mineral manuring, and specially where the nitrogen was applied as ammonia-salts, that isolated individuals acquired great vigour, and ripened seed more freely than elsewhere; though, as it would seem, from the effects of competition injurious to seedlings in general, the plant continues to show itself in isolated specimens. Under the manurial conditions in which the *Heracleum* flourishes there is a great luxuriance of the grasses, especially of a few very free-growing ones, and the question obviously arises—how far its success under these circumstances depends on the directly favourable influence of the manure on its own growth, enabling it to displace its neighbours, or how far the generally somewhat tufted and patchy character of the grasses in such cases affords space for its development?

Anthriscus sylvestris.

This is a common hedge-row biennial, with a thick, fleshy tap-root, descending some distance into the soil; it has erect stems, finely cut foliage, sometimes bright green, at other times claret-red, even in the case of two plants growing close together. It is a plant not common in pastures unless where overshadowed by trees.

It forms a constituent of but few of the samples, and indeed is observed on very few of the plots. It is absent, or nearly so, from the unmanured, the purely mineral manured, and the ammonia plots. The only conditions under which it has acquired any real prominence are those where the larger amount of nitrate of soda in conjunction with the mixed mineral manure is employed. Here, owing to the abundance of seed produced, it increased from 1·52 per cent. in the second, to 3·86 in the third, and to 4·64 per cent. in the fourth separation-years respectively. In the season of 1880 it was a very prominent plant on the same plot. Taking the whole of the plots, and the four separation-years, there is only one other instance in which the amount found in the sample reached 0·1 per cent., namely, in that from a plot adjoining the one above referred to.

Daucus Carota.—The Wild Carrot was found only in the sample from one plot, where its appearance was probably accidental.

Compositæ.

This, the largest group of flowering plants known, comprises a vast assemblage of species greatly alike as to their floral characters, but differing much in the appearance of their stem, leaves, &c. The chemical products also vary greatly. The species represented on the plots are: *Centaurea nigra*, found on a majority of the plots, *Carduus arvensis* on very few, *Bellis perennis* on more, but still only on a few, *Achillea Millefolium* on almost all, *Chrysanthemum Leucanthemum* on very few, *Senecio erucifolius* only once, *Hypochæris radicata* occasionally, *Tragopogon pratensis* on several, *Leontodon hispidus* also on several, *L. autumnalis* less frequently, *Taraxacum officinale* on a considerable number, *Sonchus oleraceus* only once, and *Hieracium Pilosella* in a few instances.

Centaurea nigra.

This common weed of pasture land forms a densely-tufted, much-branched, perennial, with a tough, woody stock, from which descend long, stout, deeply-penetrating roots. The stems are erect, rigid, 1 to 2 feet high, and branched, the branches ending in hard globose flower-heads. It flowers too late to produce seed in the first crop.

The qualities favourable to its persistence or spread are its hardiness and power of withstanding drought, and, where permitted to ripen, its free-seeding.

The following table shows the relative degree of prominence of this plant.

Table LVIII.—Relative predominance of *Centaurea nigra*.

		Centaurea nigra							
		Was First, Second, or Third, among the total Miscellaneæ, as under.				Yielded 5 per cent. or over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	..	3	..	..	..	..	..
	4-2	..	..	3	2	..	..	..	..
	5	..	3	3	..	..	..	..	..
	6	..	3	..	..	..	..	..	..
	10	..	..	3	3	..	..	..	..
	15	..	..	3	3	..	..	..	..
	17	1	3	1	3	..	..	10·28	..
Total	First	1	0	1	0	0	0	1	0
	Second	0	0	0	1				
	Third	0	3	5	3				

Thus this plant was first in quantity among the miscellaneous flora on one plot in 1862, but was not second or third in that year at all. It was third three times in 1867, but not once first or second. It was once first and five times third in 1872; and it was once second and three times third in 1877. It was, therefore, seldom first or second among miscellaneous plants; but was more frequently third. Yet it only once contributed more than 5 per cent. to the total herbage, namely, in 1872, on plot 17 (with the smaller quantity of nitrate of soda alone), and it was on this plot that the plant came first in 1862 and in 1872, and here also it was third in 1867 and in 1877. The actual percentages which it yielded to the total herbage on the plot were 4·41 in 1862, 4·10 in 1867, 10·28 in 1872, but only 2·82 in 1877. It also yielded as much as 2·58 per cent. to the produce on plot 15, with the larger amount of nitrate of soda alone, in the third separation-year. The only other plots on which it came second or third were those to which ammonia-salts were applied, but without any, or with deficient mineral manuring. With ammonia-salts and full mineral manuring it was almost completely banished. Next to the plots with nitrate of soda alone, it gave the highest percentage on the unmanured ones, where it increased up to the third separation-year, but afterwards declined.

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Achillea Millefolium.

This perennial herb is specially well endowed, having a woody, more or less branching stock, which emits slender, creeping offshoots or runners, and rather thick vertical roots giving off more or less horizontal branches destitute of root-hairs. The flowering stems are erect, terminal, dying down after flowering, thus necessitating the formation of lateral shoots (see Jour. Roy. Hort. Soc., vol. iii., 1870, p. 53). Each "runner" or stolon forms a tuft of leaves at the extremity, which ultimately becomes an independent plant by the decay of the runner which connects it to the parent stock. The leaves are crowded, spreading horizontally, and are very finely cut, whence the specific name. It does not, as a rule, flower before the first mowing, but does so before the second cutting, the flowers being probably fertilized by insects. As a rule, in this country it frequents dry pastures and banks, and bears drought well. Cattle and sheep eat it readily, and few plants sprout more freely after the browsing than this does, by reason of its mode of growth.

The characters favourable to the milfoil are its hardy constitution, and ability to withstand drought, its powerful under-ground growth, its divided stock, its habit of propagating itself by runners, and its free seeding character. These are all endowments likely to favour it in competition.

The following table shows the relative degree of prominence of this plant.

TABLE LIX.—Relative predominance of *Achillea Millefolium*.

		Achillea Millefolium							
		Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	1	..	2	2	..	..	..	5·01	..
	2	..	..	1	..	..	..	..	..
	3	..	..	..	3	..	..	..	..
	4–1.	..	..	1	..	..	..	5·38	..
	4–2.	3	3	2	..	..	..	..	..
	5	2	..	..	..	..	..	..	..
	6	2	..	2	2	..	..	..	..
	7	3	3	1	3	..	..	5·23	..
	8	..	3	1	2	..	..	9·75	..
	9	3	3	3	..	..	..	..	..
	10	3	3	2	..	..	..	..	..
	11–1	3	3	..	3	..	..	..	..
	11–2	3	..	..	..	..	..	..	..
	12	..	..	1	3	..	..	..	..
	13	3	3	3	..	..	..	..	..
	15	3	..	2	..	..	..	..	..
	16	..	3	2	2	..	..	..	..
	17	..	..	3	..	..	..	..	..
	18	—	..	1	..	—	..	..	..
Total	First	0	0	6	0	0	0	4	0
	Second	2	1	6	3				
	Third	8	8	3	4				

The milfoil was found in the samples from all the plots in 1862 and 1867; and in those from all but two in 1872, and all but one in 1877. In the first separation-year it was not first among the Miscellaneæ on any plot, but it was second on two, and third on eight. In the second separation-year (1867) it was again not first anywhere, only once second, but it was third on eight plots. In 1872 it came first on six plots, second on six, and third on three. In 1877 it was not first at all, second only on three plots, and third on four. It was only in the third separation-year (1872), when it had attained the first and second place more frequently, that it, on any plots, yielded 5 per cent. and more to the total produce. Then it did so only on four, three of which received only mineral manure; and the one of these which yielded by far the highest amount of it (9·75 per cent.) was that from which the potass had been excluded for some years, and on which the growth of the Leguminosæ, and the maturation of the herbage generally, had, in consequence, become much restricted. The plant was more favoured on the nitrate of soda than on the ammonia plots; but where the nitrate was employed in the larger quantity, and in conjunction with the mineral manures, it was in much reduced amount. Where, however, the ammonia-salts were used with the mineral manures, it was nearly banished. The conditions most favourable to it, when

thus growing in association, are, therefore, those under which the luxuriance of its neighbours is restricted. In recent seasons, probably owing to the wetness, and to the increased growth of the grasses, it has decreased on all the plots; and on the whole it is the most abundant on plot 6 (mineral manures after ammonia).

Carduus arvensis.

This, the commonest of the Thistles, on arable or on waste land, has a perennial, creeping rootstock, sending up annual stems, with prickly leaves, and heads of flowers, male on one plant, female on another. It was not, in any one separation-year, observed on more than two plots; and the only samples in which it was found were those from plot 18 (with the mineral constituents and nitrogen of one ton of hay), in 1867, and from plot 7 (mixed mineral manure including potass), in each of the four separation-years; and it only once reached as much as 0·26 per cent. of the total herbage. It would appear that this plant requires liberal supplies of mineral constituents near the surface, but that it cannot withstand the competition of luxuriantly growing associates.

Bellis perennis.

The common Daisy is well fitted to hold its own, or to spread, where circumstances permit. It has a perennial tufted stock, emitting numerous, rather fleshy, root-fibres, and branching at the top into numerous subdivisions. Sometimes, moreover, it gives off long shoots, appressed to the ground, and with a tuft of leaves at the end, capable of becoming a distinct plant. The leaves being flatly pressed to the ground, prevent the growth of plants beneath their shade.

This persistent lawn-weed has only been observed on from five to eight plots out of the 22; and it only came into the samples in 1862 from two, in 1867 from five, in 1872 from six, and in 1877 from five plots. It was found in extremely insignificant amount on three of the nitrate of soda plots, but not on any ammonia plot, or even where there was full mineral manuring. It occurred but in extremely small amount in each separation-year in the samples from one of the unmanured plots; again, in each separation-year, on the plot with superphosphate of lime alone; and in the last three separation-years on plot 1, after the discontinuance of the dung. It thus did not hold its own wherever there was any luxuriant growth of other plants. The contrary result on lawns is coincident with precisely contrary conditions of growth of the general herbage; in addition to which, it may be pointed out that the scythe or the mowing machine mutilates the appressed daisy leaves much less than it does the herbage of taller-growing species.

Chrysanthemum Leucanthemum.

This frequent ornament to cornfields and railway banks is occasionally met with in pastures. It has a tap-root, an erect, slightly-branched stem, and rather broad, coarsely-toothed leaves.

This plant was observed on only one plot in 1862, on four in 1867, on one in 1872, and on four in 1877. It did not come into the samples from any plot either in 1862 or 1867; but it was found in one in 1872, and in two in 1877, in each case in a small fraction of 1 per cent. One of the plots on which it occurred was an unmanured one. It is, however, abundant in neighbouring meadows under ordinary treatment.

Senecio erucifolius has been observed on only one plot, and only in 1872; and it has in no case been met with in the samples.

Hypochæris radicata was observed on five plots in 1867, but on one only in 1872, and has never been found in the samples.

Tragopogon pratensis.—This is a biennial plant, with a thick tap-root and long, sharply-pointed grass-like leaves. The yellow flowers are succeeded by rather large seed vessels, which are readily dispersed by means of a large pappus.

This, the Goat's-beard, was found in four samples in 1862, in five in 1867, in six in 1872, and in six in 1877; and in the last-mentioned year it was observed on one other plot. It was by far the most frequent and prominent on the unmanured plots; but it has there never yielded more than a third of 1 per cent. of the produce. The only case in which it furnished more than this was on plot 9 (ammonia-salt and mixed mineral manure), in the first separation-year, since which time it has not been found in the samples from that plot. It occurred in very small amount in each of the four samples from plot 16, with the smaller quantity of nitrate of soda and mineral manure; but otherwise, beyond what has been stated, only on deficiently-manured plots, and then in insignificant amounts.

Leontodon hispidus is a perennial herb, with spreading hispid root leaves, leafless flower-stems and yellow flowers, succeeded by feathery pappus.

The rough Hawkbit was found in 1862 in the samples from five plots, in 1867 from eight, in 1872 from six, and in 1877 from six. It only exceeded 1 per cent. of the total produce on one of the unmanured plots, on which it gradually increased. Next to the unmanured, it was most prominent on plot 4–1 (superphosphate of lime alone), but it did not there reach to 1 per cent. of the total herbage. The other plots on which it occurred were those characterised by more or less exhaustion, and little or no luxuriant growth.

Leontodon autumnalis is a Composite with perennial root-stock, branching at the top and bearing tufts of spreading, nearly glabrous, narrow, lobed leaves. The flower-heads are small and relatively few, and the pappus feathery. *L. autumnalis* was much less frequent in the samples than *L. hispidus*. It was found in only one sample in

1862, in three in 1867, in one in 1872, and in one in 1877. In every case it was present in extremely insignificant amount.

Taraxacum officinale.—The root-stock of this plant is very stout, descending deeply into the ground, and dividing at the summit into numerous subdivisions, each with its tuft of rather broad appressed leaves. The flower-stalks have no leaves, and the brilliant yellow flowers are succeeded by light feathery pappus. The common Dandelion was found in 1862 in 17 samples, in 1867 in 16 (but observed on one more plot), in 1872 in 13, and in 1877 in 10—in a decreasing number, therefore, from period to period. In only one case did it contribute more than 1 per cent. to the produce, and that was with the larger amount of nitrate of soda alone (plot 15) in the first separation-year, after which it nearly disappeared from that plot. In one instance it reached to 0·63 per cent., viz.: on the plot with the larger quantity of nitrate of soda and mineral manure, and in the last separation-year. This was the only plot on which it increased. The other plots on which it was the most frequent were those without manure, or with deficient mineral manuring. It was all but absent from the plots liberally manured with ammonia-salts. Thus, although in no case was the amount large, the only conditions under which this plant increased were those of a liberal supply of nitrate of soda and mineral manure; whereas when with the same mineral manure the nitrogen was applied as ammonia-salt the plant was practically banished. It would seem that the maintenance of its position, though dependent on liberal manuring, was also much influenced both by the character of the seasons and by association.

Sonchus oleraceus.—This cornfield weed never occurred in sufficient amount to be found in the samples, and was only once observed, viz.: on plot 14, in the third separation-year (1872).

Hieracium Pilosella.—A low-growing perennial, with a tufted stock, and long creeping barren shoots, which enable the plant to insinuate itself between others, and take possession of vacant spaces. This plant was found in 1862 in three samples, in 1867 in four, in 1872 in three, and in 1877 in three (but was also observed in that year on one other plot, 1). It was the most frequent and prominent on the unmanured plots, but in no case did it yield 0·1 per cent. of the total produce.

The foregoing statements show that only three species of the Order *Compositæ* have maintained any special prominence on the plots, viz.: *Centaurea nigra, Achillea Millefolium,* and *Taraxacum officinale;* but the conditions under which these plants, respectively, have been the most developed, are by no means so uniform as to allow of any satisfactory generalisation in regard to the Order as a whole. This, indeed, could hardly be expected when the varying habit and organisation of the plants constituting this widely-diffused family are considered.

PLANTAGINACEÆ.

This is a small Order, the species of which are very similar in habit. *Plantago lanceolata* and *P. media* are the only species found on the plots. The species generally affect dry places, and are often found by waysides. They are natives almost exclusively of temperate regions.

Plantago lanceolata.

The common Rib-grass is a perennial, tufted plant, bearing close rosettes of lanceolate leaves, which spread flat on the ground at first, or where there is no impediment; but subsequently they assume a more or less erect direction. The stock is thick, strong, descending to a considerable depth, giving off numerous long, rather fleshy, root-fibres. The root-hairs are thin, long, delicate, sometimes consisting of more than one cell. It flowers in May, and continues to do so in succession throughout the summer. It is protogynous, and generally wind-fertilised; its seeds are matured before the first, and again before the second crops are removed.

It is a variable plant, and in the Chiswick experiments (Jour. Roy. Hort. Soc., vol. iii., 1870, p. 157) numerous self-sown seedlings appeared under the different conditions of manuring, which presented considerable variations in shape and colour of leaf, pubescence, &c.; variations which could not be attributed to the immediate operation of external conditions, seeing that they appeared in all the boxes indifferently, and in each box under the same conditions. At Rothamsted, in like manner, we have seen a hairy and a glabrous-leaved variety in juxtaposition on the same plot. In severe frosts the outermost leaves of the tuft are liable to be injured, the younger central ones being unhurt. One consequence of this is, that a hardier plant in proximity to it has an immediate advantage, and commences to occupy the space left by the dead or decaying foliage, before the growth of the young leaves in spring. These latter, from the pressure exerted on them, are made to assume an ascending direction.

The endowments favourable to the Rib-grass are its generally hardy constitution, as shown by its general distribution over more than a third of the surface of the globe. Its dense, somewhat thick foliage, and its powerful and persistent root-stock also tell in its favour. The freedom with which seeds are produced also tends to perpetuate the species, even if the individual plants succumbed in the struggle. The following table shows the relative degree of prominence of this plant.

TABLE LX.—Relative predominance of *Plantago lanceolata*.

		Plantago lanceolata							
		Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	2	..	1	..	1	..	..	..	..
	3	1	1	..	2	7·34	10·73	..	..
	4-1	2	1	..	2	5·63	9·66	..	..
	12	1	1	..	..	7·74	8·25	..	..
	15	1	2	..	..	6·92	..	..	..
	17	2	2	..	1	..	..	..	7·99
Total	First	3	4	0	2	4	3	0	1
	Second	2	2	0	2				
	Third	0	0	0	0				

Plantago lanceolata was found in the samples from 16 plots in 1862, 14 in 1867, 14 in 1872, and 16 in 1877; in 1862 it came first on three plots, second on two, but third on none; in 1867 it came first on four plots, and second on two; in 1872 it did not come either first, second, or third on any plots, but in 1877 it was again first on two, and second on two.

It yielded more than 5 per cent. to the produce on four plots in 1862, on three in 1867, on none in 1872, and on only one in 1877.

The conditions under which it asserted prominence to the degree shown by the table are significant. It so occurred on only six plots: the two unmanured ones, the plot unmanured for some years after the application of farmyard manure, the plot with superphosphate of lime alone, and the two plots with nitrate of soda without mineral manure. Four of the six plots were therefore characterised by extremely restricted growth of the herbage in general, and the remaining two (nitrate of soda alone), by imperfect development and maturation.

Even with the nitrate of soda and mineral manure together, the more vigorous growth induced in its associates was adverse to this plant.

With ammonia-salts, both with and without mineral manures, it was very much reduced, and in many cases banished—at least to such an extent as not to appear in the samples.

Upon the whole, then, this plant has decreased, or even disappeared entirely, on all plots where there was general luxuriance; and whether from direct action of the manure, or from competition, it has suffered much more under the influence of ammonia-salts than under that of nitrate of soda. The results of the observations at Chiswick (see Jour. Roy. Hort. Soc., vol iii., 1873, p. 144) would seem to show that the action of ammonia was directly adverse to the plant, whereas that of nitrate of soda was not so.

The general result would then appear to be due, partly to the direct effect of manures, and partly to association. In any case the plant seems to be steadily declining, and it is, at any rate, satisfactory to know that it may be eliminated by encouraging the growth of more valuable species.

Plantago media, a weed of dry lime-stone districts, was not found in any of the samples, and was only observed on one occasion, viz.: on plot 4–1 in 1867.

Polygonaceæ.

The Docks and Sorrels are the only representatives on the plots of this Order whose members are so readily recognised by their "ochreate" stipules and floral characteristics. The herbaceous species are most abundant in temperate regions, extending to the arctic regions on the one hand, and into sub-tropical countries on the other. A few, and these of arborescent habit, occur in tropical and sub-tropical America. It would seem, then, on the whole, that these plants can adapt themselves to almost any climatal condition except the excessive heat and moisture of the tropics.

Rumex Acetosa.

The Common Sorrel is a perennial, with a thick, somewhat woody, much branched rhizome, giving off stout, yellowish, relatively little branched, but deeply penetrating roots, often forming a dense mass of fine fibres, but destitute of root-hairs. The flowers are dicecious, the males on one plant, the females on another. It would be interesting to observe whether any, and if so what, differences exist on the several plots, or in different seasons, in the relative abundance of male or female plants. It flowers in May, and continues to do so throughout the summer, producing seed abundantly. On the bare places, on almost all the plots, seedlings of this plant were observed in the spring of 1875, as also in other years, but less conspicuously.

The characteristics which are likely to be of advantage to this plant when growing in association are its hardiness, robust habit, deep and free-rooting, ample storage of water and nutritive matters in its root-stock, and its abundant production of seed.

The following table shows the relative degree of prominence of this plant.

TABLE LXI.—Relative predominance of *Rumex Acetosa*.

	Rumex Acetosa							
	Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
	1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots 1	1	1	1	1	6·09	5·74	9·29	10·49
2	1	2	2	3	12·44	..	..	..
4–1	3	2	..	3	..	5·47	..	..
4–2	1	1	1	1	13·39	8·42	6·85	..
5	1	1	1	1	9·15	15·94	7·13	..
6	1	1	1	1	12·11	24·27	7·51	7·66
7	1	2	..	1	..	8·88	..	6·67
8	1	1	3	1	..	7·86	..	5·84
9	1	1	1	1	5·40	10·89	..	..
10	1	1	1	1	10·38	12·61	..	5·99
11–1	1	1	1	1	7·02	..	..	..
11–2	1	1	1	1	..	..	..	..
12	2	3	2	..	..	..	..	..
13	1	2	1	1	5·48	..	..	6·84
14	1	3	2	2	6·88	..	..	..
15	2	1	..	1	6·64	7·34	..	5·79
16	1	1	3	1	5·46	5·62	..	..
17	3	1	..	..	..	7·53	..	..
18	—	1	..	1	—	24·33	..	..
19	—	—	..	2	—	—	..	..
20	—	—	..	3	—	—	..	..
Total First	14	13	9	14	12	13	4	7
Total Second	2	4	3	2				
Total Third	2	2	2	3				

Evidences of the existence of this plant were found in the samples taken from all the plots (19) in 1862, from all (20) in 1867, from all (22) in 1872, and from all (22) in 1877, that is, on every plot in each separation-year. In 1862 it was first in percentage among the total miscellaneous herbage on fourteen plots, second on two plots, and third also on two; in other words, it was either first, second, or third on eighteen out of nineteen plots in that year. In 1867 it was first on thirteen plots, second on four, and third on two, or so far prominent on 19 out of 20 plots. In 1872 it was first on nine plots, second on three, and third on two, or first, second, or third on only 14 out of 20. Lastly, in 1877 it was first on fourteen plots, second on two, and third on three, or again very prominent on 19 out of 22 plots.

It yielded more than 5 per cent. of the total produce on 12 plots in 1862, on 13 in 1867, on four only in 1872, and on seven in 1877.

The only plots upon which it did not come first in one or more of the four years were the two unmanured plots, and plot 4–1 with superphosphate of lime alone. It was in 1867 that it acquired its greatest predominance, and both in that year and in

the others it was on the plots manured with ammonia-salts that it contributed the largest proportion of the total miscellaneous herbage. On two ammonia plots in 1867 it contributed nearly a fourth of the whole produce, and on several others a very large amount. But it yielded less where the combination of mineral manures with the ammonia-salts was such as to favour the luxuriance and maturation of the grasses. With nitrate of soda the produce of this plant was much less than with ammonia-salts, and especially when mineral manures were used in conjunction with the nitrate.

It is obvious that the *Rumex Acetosa* is a gross feeder, and that it is favoured by ammonia-salts rather than by nitrate, but that it is restricted in development when the conditions of manuring are favourable to the luxuriant growth of the grasses. It has, disregarding some exceptions, yielded less to the produce in recent years than formerly. It continues to find its most favourable conditions on the ammonia plots, particularly when they are used in conjunction with minerals. It also exists to a large extent on the nitrate plots. Its most prominent associates among the grasses are —*Festuca ovina*, *Dactylis glomerata*, *Poa trivialis*, *Holcus lanatus*, *Avena pubescens*, *A. flavescens*, and *Bromus mollis*. Among Leguminosæ, its most conspicuous associate has been *Lathyrus pratensis;* and among the Miscellaneæ, *Achillea Millefolium*.

It would seem that this objectionable weed is by no means so readily displaced by high manuring, and the competition consequent on it, as the Plantago and some others; for it flourishes under the influence of ammonia-salts, and it is only when these are associated with a liberal admixture of mineral constituents that the grasses seem to have the power of overcoming it

Rumex crispus.—The curled Dock, like its congeners, has a thick, almost woody, root-stock, which descends into the ground, and, while thus securing a position and a hold, stores up nutriment and water in its tissues, which give it a great advantage in the battle of life. It is, however, not found in any quantity on the plots. It was observed on two plots in 1867, on two in 1872, and on two in 1877; but it was only once found in a sample, viz.: in that from plot 14, in 1877.

Rumex obtusifolius has almost the same habit as the preceding, from which it differs mainly in the leaves. It was observed on one plot in 1867, on one in 1872, and on one in 1877, but was never found in any of the samples.

Of the three species above mentioned, *Rumex Acetosa* is more especially a moist pasture plant, growing in association with other plants; while the Docks are more particularly plants of waste places, waysides, and arable land, growing in masses where other plants less robust in character do not find the conditions suitable for their well-doing.

JUNCACEÆ.

The species of this Order are distributed throughout the world, the true Rushes (*Juncus*) being found chiefly in wet, marshy places, and having relatively small development of their leaves; while the Woodrushes (*Luzula*) generally occur in drier

localities, and have broader and more grass-like foliage. The latter genus alone is represented on the plots.

Luzula campestris.

The field Woodrush is a small tufted perennial, with a creeping root-stock, sometimes giving off offsets. The true roots are fine, and do not penetrate deeply. The leaves are linear and grass-like. It flowers in early spring, is protogynous, is wind-fertilised, and produces abundance of seed, which sheds before mowing.

Although nowhere forming a very prominent feature of the vegetation, it is one of the most widely distributed plants known, being found in the northern hemisphere from the Arctic regions to the Mediterranean; in America, from Canada to South Carolina; as well as in Australia, New Zealand, and the Cape of Good Hope. Any climate, therefore, except an extremely hot or dry one, will suit the plant. It seems to be equally indifferent to the nature of the soil; but in this country it is usually found in association with grasses, &c., in pastures and meadows. The circumstances that would seem to favour it in its struggle with other denizens of meadow land are the same as those which enable it to exist over so wide a geographical area. Its hardiness, creeping root-stock, and abundance of seed, all give it an advantage; though only once has it been found to take the most prominent place among miscellaneous plants, and then on the unmanured plot.

TABLE LXII.—Relative predominance of *Luzula campestris*.

		Luzula campestris							
		Was First, Second, or Third, among the total Miscellanea, as under.				Yielded 5 per cent. and over, to the total Mixed Herbage, as under.			
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.
Plots	3	3	2	1	..	..	..	..	..
	4–1	..	..	3	..	..	..	..	..
	6	3	..	..	3	..	..	..	..
	7	..	..	2	..	..	..	..	..
	8	..	..	2	..	..	..	..	..
	19	—	—	3	..	—	—	..	..
	20	—	—	2	..	—	—	..	..
Total	First	0	0	1	0	0	0	0	0
	Second	0	1	3	0				
	Third	2	0	2	1				

It was found in the samples from 16 out of 19 plots in 1862, from all (20) in 1867, from 19 out of 22 in 1872, and from 18 out of 22 in 1877, but it was observed on one more in that year.

In 1862 it came neither first nor second among miscellaneous plants on any plot, but was third on two. In 1867 it was second on one; in 1872 it was first on one, second on three, and third on two; in 1877 it was neither first nor second on any plot, and third only on one. But notwithstanding this apparent predominance on several occasions, it in no case contributed 5 per cent. to the total produce.

Its highest percentages were on the plots without manure, with superphosphate of lime alone, and with the mixed mineral manure, excluding potass. On these plots it, for the most part, increased in amount up to the third separation-year, but afterwards diminished. It was almost excluded from all the ammonia plots, especially where the manuring was highest. With nitrate of soda alone it fared better than with ammonia-salts alone, but with nitrate of soda and mineral manure together it speedily became reduced to an insignificant amount. Of recent years it has been most abundant on the unmanured plots, and on the plot with superphosphate of lime only.

Thus this plant fortunately only becomes at all prominent under poor conditions of manuring, and restricted growth of the herbage generally.

We now return to the consideration of those Orders no member of which has attained such a degree of prominence as to come first, second, or third among the miscellaneous plants, or to yield 5 per cent. of the total produce.

Cruciferæ.

The only representative of this well marked and important family is *Cardamine pratensis*, a plant usually found in damp, rich meadows, and sometimes in great profusion, but which has only been observed on two of the experimental plots, and only in the third separation-year. That it does not occur more frequently, and in greater quantity, is probably due to the good natural drainage afforded by the chalk a few feet below the surface.

Hypericaceæ.

Hypericum perforatum is the only member of this group found on the plots. It has only been found in the samples from the plot receiving the smaller quantity of nitrate of soda alone, then only in two of the four separation-years, and in each case in very insignificant amount.

Rosaceæ.

The species of this Order, though so numerous and so widely diffused, do not, as a rule, contribute in any very marked proportion to the herbage of pasture land in this country. The following species have been observed on the experimental plots:—

Potentilla reptans.—This plant was found in six samples in 1862, in six in 1867, in nine in 1872, and in 10 in 1877, but it was observed on 16 plots in that year. In only one case did it contribute 0·25 per cent. to the produce; in only two 0·1, and in all the

rest extremely small amounts. It was most frequent on the unmanured plots; but it gave the largest amount with nitrate of soda alone. From its creeping habit it might have been expected to take a more prominent position.

Potentilla Fragariastrum was found in only one sample in 1867, one in 1872, and one in 1877, in each case from the unmanured plot. It is not a characteristic pasture plant.

Alchemilla vulgaris did not come into any sample, was only observed on one of the unmanured plots (3), and there only in the fourth separation-year. Nevertheless, it is not uncommon in the adjoining pastures.

Agrimonia Eupatoria occurred in the samples from two plots in 1862, four in 1867, five in 1872, and four in 1877, but it was observed on six in that year. Excepting twice in very small amount on one of the nitrate plots, it was only found on the unmanured plots, or on those supplied with a partial mineral manure; in every case in insignificant quantity.

Poterium Sanguisorba was found in one sample in 1862, and in two in 1867, 1872, and 1877 respectively. The only plots on which it was thus found were one of the unmanured, and the adjacent one with superphosphate of lime alone. On the latter it rather diminished in amount, while on the unmanured plot it increased, but not to such an extent as to contribute in the last separation-year as much as 1 per cent. of the produce.

Spiræa Ulmaria occurred in the samples from one plot in 1862, two in 1867, three in 1872, and six in 1877. It has not occurred on either of the unmanured plots, and has maintained its position the best on plot 7 (with the mixed mineral manure including potass). It has not been found on any of the nitrate plots, or on either of those with the highest quantity of ammonia-salts; and on the others where it occurred it has declined to an insignificant amount. In no case has it reached ½ a per cent. of the produce, and it has been generally represented by less than 0·1 per cent.

Rubiaceæ.

With the exception of some species of *Galium*, the members of this Order are not characteristic of pastures.

Galium verum occurred in five samples in 1862, but was observed on 14 plots; in eight samples in 1867, and was again observed on 14 plots; in 10 samples in 1872, and observed on 15 plots; and in 14 in 1877, but it was observed on 19 plots. It was present in very small quantity, or not at all, on the unmanured plots, scarcely at all on the plots with the purely mineral manure, but it was in larger amount, and sometimes increased, where ammonia-salts were used, either alone or with deficient mineral manuring. But where the ammonia-salts were combined with full mineral manuring it was practically banished. Its highest yield was 2·4 per cent. with ammonia-salts alone in the third separation-year; and it twice yielded more than 1 per cent. on the

plot with the larger amount of nitrate of soda alone. In all other cases it yielded under, and in most very much under, 1 per cent.

Galium Aparine was much less frequent than *G. verum*. It was found in only one sample in 1862, in none in 1867, in two in 1872, and in seven in 1877. The amount in which it occurred was in all cases insignificant. On none of the plots highly manured with both nitrogen and mineral constituents did it occur at all; but, nevertheless, it did so more frequently with than without nitrogenous manure. The plant, by reason of its rampant growth, hooked prickles, and great facilities for diffusion by means of its bur-like seed-vessels, would seem to be well fitted for the struggle with its associates. It is clear, however, that it has no chance against them except under conditions unfavourable to their growth.

Dipsaceæ.

Few of the species of this small Order are pasture plants.

Scabiosa arvensis is the only one that has been met with on the plots. It is a coarse, strong-growing perennial, with a stout root-stock. It occurred in the samples taken from seven plots in 1862, five in 1867 (but was observed on one more), 10 in 1872, and 11 in 1877. It was generally found on the unmanured plots, but in very insignificant amount. It was absent, or very nearly so, wherever there was liberal nitrogenous and mineral manuring, but it reached as much as 0·3 per cent. with the smaller quantity of nitrate of soda alone; and it reached its highest percentage on the plot with ammonia-salts alone, where in 1862 it yielded 0·03 per cent., in 1867 0·28, in 1872 0·62, and in 1877 1·67 per cent.

Scrophulariaceæ.

The only representatives of this large family found on the plots are two species of *Veronica*. None of the parasitic species of *Rhinanthus*, *Bartsia*, or *Melampyrum* occur, though they are not wanting in the neighbourhood.

Veronica Chamædrys occurred in 13 samples in 1862, and was observed on 14 plots; in 14 samples in 1867, and was observed on 15 plots; in 14 samples in 1872, and 13 in 1877; but in both these years it was observed on 16 plots. It was scarcely represented at all on the ammonia plots, but was slightly more so on the nitrate plots. It occurred in largest quantity on the plots without manure after farmyard manure, without manure from the commencement, and with purely mineral manure. It only exceeded 1 per cent. of the produce on the plot which had previously received farmyard manure, and was afterwards left unmanured. As the foregoing statements will show, this plant occurred pretty frequently on the plots, notwithstanding its weak and humble growth, and it was sometimes plentiful among the bottom herbage, its creeping habit enabling it to co-exist with the grasses.

Veronica serpyllifolia was observed on one plot only in 1867 and in 1872, and was found in two samples in 1877, and then only in small fractional proportion; otherwise not at all. The plots on which it thus occurred were 3, 4–1, 15, and 17; that is, without manure, with superphosphate alone, with mineral manure after nitrate, and with nitrate of soda alone.

Labiatæ.

This large and well-characterised Order contributes but few species to the Rothamsted pastures, and the proportion in which they occur is but trifling.

Prunella vulgaris has procumbent or trailing stems, and from its hardiness, exceedingly wide geographical distribution, and frequency of occurrence in the immediate neighbourhood, might have been expected to form a more prominent constituent of the herbage of the plots than it does. It was found in three samples in 1862, in six in 1867, in six in 1872, and in seven in 1877. In the last-named year it was also observed during growth on 12 of the plots. It was met with in each separation-year in the samples from the unmanured and the superphosphate plots; though in no case did it contribute 0·1 per cent. to the herbage. Its amount in any other samples was quite insignificant.

Thymus Serpyllum, the common Wild Thyme, from its perennial duration, hard, wiry, procumbent, and much-branched stems, and dense habit, might have been expected to occur more frequently on the plots, particularly as it is not uncommon in the neighbourhood. It was found only in two samples, those from the unmanured plots, in the fourth separation-year (1877).

Ajuga reptans, the common Bugle, is a pasture plant, occurring throughout the whole of Europe and temperate Asia. Its stock produces somewhat fleshy, relatively unbranched root-fibres, and dense tufts of leaves, from amid which creeping offsets are given off, which root at the nodes, and form distinct plants. It was found in three samples in 1862, in five in 1867, in seven in 1872, in 10 in 1877, and was observed on one other plot in that year. It occurred most frequently in the samples from the unmanured plots, from the plot with superphosphate of lime, and from that with the smaller quantity of nitrate of soda. In the samples from the last-named plot it reached its highest percentage; but, like the *Prunella*, it never contributed as much as 0·1 to the total herbage.

All three of the above-mentioned Labiates possess in their organisation and constitutional characters attributes which would lead us to expect to meet with them in larger proportions on the experimental plots; but it is evident they cannot surmount the opposition offered by other plants, when these are stimulated by conditions of high manuring.

Primulaceæ.

Primula veris, the common Cowslip, is the only member of this family found on the plots, and it is so only in small quantities. It was found in four samples in 1862 (but observed on six plots); in two samples in 1867 (and observed on six plots); in one sample only in 1872; and in six in 1877 (but observed on eight plots). It was most frequent on the unmanured and the mineral manured plots; but in all cases it yielded an extremely small quantity, and it was all but absent from all plots receiving nitrogenous manure.

Orchidaceæ.

Orchis Morio is the only species of this family observed on the plots. It was present on three in 1862, on none in 1867, on one in 1872, and on one in 1877, these being the unmanured, and one of the mineral manured plots; but it was never in sufficient quantity to be represented in the samples.

Liliaceæ.

Three species represent this Order, viz.: *Scilla nutans*, *Fritillaria Meleagris*, and *Ornithogalum umbellatum*.

Scilla nutans, the Blue Bell or Wild Hyacinth, was found in one sample in 1862, in none in 1867, in three in 1872, and in six in 1877. It occurred on plots very variously manured, but in no case exceeded 0·01 per cent. of the total herbage.

Fritillaria Meleagris has not been met with in any of the samples, but a few plants were observed on two plots in 1867, on one in 1872, and on one in 1877; in each year on the plot with the smaller quantity of nitrate of soda alone. The plant occurs with some frequency in the Park, under some elm-trees at a little distance from the plots, but appears to have quite disappeared from the plots of late years.

Ornithogalum umbellatum was found in extremely small amount in one sample (from plot 9) in 1872, but has otherwise not been observed on the plots.

All three of these *Liliaceæ* are bulbous plants, flowering early, and are not of a character to be represented in the samples, even in the small proportion in which they exist in the growing herbage. The organisation of the bulbs is such as to provide for reproduction independently of the seed, and thus it not unfrequently happens that the plants persist for some years, forming new bulbs and leaves each season, but not producing flower. The same holds good in the case of the Orchids. The profusion of Blue Bells in woods and shady places probably arises from the circumstance that they are enabled to grow and maintain themselves under conditions in which other plants cannot so well do so.

Cyperaceæ.

The Sedges are well nigh as widely distributed as the Grasses; but they are more especially plants of wet places. The contrast between the plants of the two Orders is very interesting, but the experimental plots afford but little opportunity for illustrating it, inasmuch as there is only one of the Order met with on them, viz.:—

Carex præcox, which is a slow-growing, tufted, early-flowering Sedge, with creeping root-stock, giving off fibrous roots. It is very generally diffused in meadows, even on those which are relatively dry. It was found in 12 samples in 1862, in 13 in 1867, in 16 in 1872, and in 10 in 1877. It was most frequent on the unmanured plots and on those with purely mineral manures. It was all but absent from the ammonia plots; but it was more general on the nitrate plots. It yielded by far the largest quantity to the herbage on the unmanured plots. In only two cases, however, did it contribute more than 1 per cent. to the produce.

Filices.

Ophioglossum vulgatum, the Adder's Tongue Fern, is the only representative of this order which has been met with on the plots. It is a low-growing species, with a small, perennial, creeping root-stock, throwing up a single ovate leaf, which is apt to escape observation amid the more luxuriant herbage, and even if it be not withered before the grass is cut, is of such lowly stature as not often to come into the samples. It was found in four samples in 1862, in none in 1867 or 1872, and in one only in 1877. Its presence was, however, noted on four plots in 1867, on four in 1872, and on three in 1877. Its amount in every instance was so small as to require no further comment.

Musci.

Three species of *Hypnum*—*H. squarrosum*, *H. rutabulum*, and *H. hians*—occur on the plots. One or other of these was found in 10 samples in 1862, in eight in 1867, in 15 in 1872, and in 20 in 1877. They were by far the most frequent on the unmanured plots, and on those receiving mineral manure alone. They were scarcely represented at all on the ammonia plots, but were more general on the nitrate plots. In only two cases did the amount reach or exceed 0·1 per cent., and these were on the plots without manure and with superphosphate of lime alone. In all others the quantity was extremely insignificant. The evidence is, that their presence in the mixed herbage is more directly dependent upon the amount of water at command, and on the absence of luxuriance of their associates, than on manurial conditions specially favourable to themselves.

THE BOTANY OF EACH SEPARATE PLOT, IN EACH SEASON OF COMPLETE SEPARATION.

Thus far we have described the arrangement of the experiments, the mode of experimenting, and the characters of the seasons preparatory to and during the periods of growth of the four crops selected for complete botanical separation; we have given a complete list of all the plants, either found in the samples or observed growing on any one of the whole series of 20 (or more) plots; we have called attention to the general prevalence of certain plants, and to the characters, structural or physiological, above-ground or under-ground, which may be supposed to influence the results of the struggle, when numerous species are growing in association, and when conditions are provided which unequally affect the activity of growth of the different components of the mixed herbage. Finally, the actual or relative characteristics of growth of each species found in the samples, or observed on the plots, have been briefly described; and it has been pointed out, under what conditions of manuring each has maintained or improved its position, or has succumbed in the combat with its associates under the more active competition which has been induced.

It remains to describe the botanical composition of the collective herbage of each of the differently manured plots, in each of the four seasons of botanical separation; to direct attention to the changes in the flora, from one separation-year to another, under the different conditions; and to consider the character of the changes—whether apparently progressive and regular, and probably due almost exclusively to the conditions induced by exhaustion or by manuring; or whether they are probably materially influenced by the characters of the seasons to which the associated species have been exposed.

It is obviously essential, as a means of discriminating between the results primarily due to the conditions of manuring, and those greatly dependent on the characters of the seasons of growth, to bear in mind what were those characters, and what was the nature of their influence in determining to luxuriance or to maturation, and so on. It will be desirable, therefore, as a preliminary to the discussion which is now to follow, very briefly to summarise in this place the climatal characters of the different seasons, referring for more detail to the fuller consideration of the subject at pp. 1188–1206.

First season of separation, 1862.—This, the first season of complete botanical separation, was the seventh in the course of the experiments. Dependent on previous conditions, there were full average second crops in 1861. The autumn and winter of 1861–2 were warmer and drier than usual, excepting November, which was cold and wet. In 1862 the grass-growing months were wetter than the average, and also warmer, excepting June, which was wet and cold, protracting growth, but not maturing. The experimental crops were generally considerably over the average. The climatal conditions were favourable to the prominence of the grasses, especially of the freer-growing ones, also of free-growing weeds, and especially *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium*. The herbage was characterised by abundance

of foliage, dense undergrowth, backwardness, and little tendency to form stem, or to flower and seed.

Second season of separation, 1867.—In 1866 both the first and second crops were over average, and the second were cut and left on the ground. The autumn, winter, and spring of 1866–7 were very changeable, and growth was much checked. June, the maturing period, was again changeable; upon the whole drier, but not so warm as usual. With very varying climatal conditions, there was great irregularity in the character of growth of the different plants, and with the different manures. Without manure, and with deficient manuring, there was more than average produce; with mineral manure and ammonia-salts together there was a considerable deficiency; and with mineral manure and nitrate of soda a considerable excess. With the nitrate the excess was almost all gramineous, and the most forward grasses produced much stem, under the influence of the dry, though not warm, weather of June. With deficient manuring, and with ammonia-salts alone, there was, on the other hand, restricted growth of the grasses, but miscellaneous plants were unusually abundant. Upon the whole, the different grasses were very differently affected; Leguminosæ were generally deficient; miscellaneous plants were in excess; and, excepting with the nitrate, the growth was much more characteristically leafy than stemmy.

Third season of separation, 1872.—The characters of the seasons intermediate between the separation-year of 1867 and that of 1872 undoubtedly exercised considerable influence on the struggle from year to year. The first of the four intermediate years gave very heavy produce, characterised by great stemminess and maturity; the second, again, gave very heavy produce, but characterised by great luxuriance and leafy growth; the third yielded the smallest crop of the whole series, prematurely ripened; the fourth was one of variable characters, giving more than average amounts of produce, with great unevenness of development of the plants. It is obvious that these various conditions were calculated to influence the character and results of the struggle in very various ways; and, in the facts adduced, we have illustrated in a striking manner how greatly the question is complicated by the element of season.

The season of 1872 itself was extremely changeable; favourable for fair luxuriance, but of very varying tendency to stem and seed formation, and to maturation, according to the already established character of the herbage, and to the conditions of manuring supplied. There was generally less than average produce with deficient, and more than average with high, manuring. By virtue of the characters of the four preceding seasons, and especially of the two years of heat and drought, 1868 and 1870, the distribution of plants had become considerably modified. With deficient manuring *Festuca ovina* especially, but *Agrostis vulgaris* also, had much increased. With more liberal manuring, when the nitrogen was supplied as ammonia, *Dactylis glomerata* and *Poa pratensis*, and when as nitrate, *Bromus mollis* and *Poa trivialis* had become more prominent. The season of 1872 was favourable for superficially feeding Leguminosæ

where the manures were appropriate. Miscellaneous plants had been generally reduced; but *Rumex Acetosa* had maintained its position, *Achillea Millefolium* had considerably increased, and *Conopodium denudatum* was also prominent.

To conclude,—with considerably modified floras, induced by recent seasons of luxuriance, or of drought, or of both, and with very variable climatal conditions in the season of separation itself, for the most part more favourable for luxuriance than maturation, and the ripening period both late and much broken, there were very variable characteristics of produce on the differently manured plots.

Fourth season of separation, 1877.—In the first crops of 1873 the grasses were dwarfish, with little stem and thin undergrowth; some strong weeds—such as *Rumex Acetosa*, *Centaurea nigra*, and *Achillea Millefolium*—were luxuriant, but Leguminosæ were less prominent than usual. There was fairly dense aftergrowth yielding two cuttings, which were spread on the respective plots. *Festuca ovina* contributed a large proportion of the dense undergrowth.

The winter and early spring of 1873–4 were warmer but drier than usual, and vegetation was very backward. With continued drought and low temperatures the herbage was materially damaged, yielding stunted and injured crops. There was comparatively little aftergrowth, excepting with high manuring; second and third crops were, however, cut, and spread on the respective plots.

In the winter and early spring of 1874–5 the weather was very variable; but there was an excess of rain, and there were higher than average temperatures in May and June. The produce was generally below, but with high manures it was above average. *Agrostis vulgaris* and *Poa trivialis* were very prominent; and the dense, leafy growth of the grasses kept back the leguminous and miscellaneous species. The comparatively meagre first growth was followed by great luxuriance of free-growing species, such as, according to the plot, *Dactylis glomerata*, *Avena elatior*, and *Bromus mollis*. Leguminous and miscellaneous plants were also prominent and prolific. The second cuttings were much heavier than usual, and they were, for the first time, removed from the land and weighed—a procedure obviously affecting the condition of the land, and at the same time introducing a new element into the struggle among the components of the mixed herbage.

The winter and early spring of 1875–6, and the usual growing period, were variable and unseasonable, yielding backward, scanty, and thin crops, excepting with the highest manuring, where a few free-growing grasses were luxuriant. Leguminous and miscellaneous species were deficient. The autumn was wet, but variable as to temperature, and the second growth of the grasses was accordingly patchy, but with a good deal of leafy bottom; whilst both leguminous and miscellaneous species were deficient. Owing to the wetness and coldness of the weather, the second crops could not be weighed and removed, but were cut and spread on the respective plots.

In 1877, the year of botanical separation itself, grass gave great early promise, but it was much checked by a cold spring, and it remained backward, short, and benty,

with little undergrowth, until, with warm weather in June, the herbage thickened surprisingly, yielding, eventually, more than average produce, especially on the highly-manured plots, where free-growing grass prevailed. There was, however, considerable irregularity of development, excepting with the nitrate of soda.

Thus, between the third and fourth separation-years, 1872 and 1877, there were several seasons of more or less ungenial weather for the growth of first crops, which were only average or under average; and those of the second year were both under average and much damaged by the dryness and coldness of the growing period. The second crops of the period were, however, over average, and those of the third intermediate season (1875) were not only very heavy, but were removed from the land. Finally, the year of separation itself was one of early promise, then checked growth, but eventually luxuriant and heavy produce, with, however, very uneven development on the different plots. The general result was an increased proportion of gramineous herbage, especially of the freer-growing grasses, where there was liberal manuring.

1. *Without manure; Plots* 3 *and* 12.

Before describing in detail the botany of the manured plots, it is essential to study carefully that of the unmanured plots 3 and 12, both separately and comparatively. We shall thus gain an idea of the natural vegetation of the experimental area. By comparing the composition of the herbage on one plot with that on the other, we shall be able to form an approximate estimate of the range and the limits of variation on ostensibly duplicate areas; and by comparing the results of one year with those of another, we shall learn something of the character of the changes induced by variations of season, by the constant competition and struggle, and by progressive exhaustion, irrespectively of the influence of manure. Further, we shall acquire standards with which to compare the results obtained on the manured plots.

The following Tables LXIII. and LXIV., pp. 1294, 1295, give a complete numerical record of the botany of the two unmanured plots, in each of the four separation-years. In Table LXIII. is given the number of species found in the samples, grouped as "Gramineæ," "Leguminosæ," and "Other Orders" (all the miscellaneous species being arranged under this heading); in it the percentage of each species in the total mixed herbage is also recorded. In Table LXIV. the actual quantity of each species, in lbs. per acre, is given. The mean results for each plot over the four years, as well as the difference between the one plot and the other, are also shown.

TABLE LXIII.—Number of Species, and Proportion per Cent. (by weight) of each Species, Without Manure; Plots 3 and 12.

		Plot 3.				Plot 12.				Mean of 1862, 1867, 1872, 1877.		
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.	Plot 3.	Plot 12.	Plots 3 and 12.
NUMBER OF SPECIES.												
	Grasses	18	18	17	17	16	16	17	16	17	16	17
	Leguminosæ	4	4	4	4	4	4	4	4	4	4	4
	Other Orders	28	24	28	31	24	30	29	31	28	29	28
	Total	50	43	49	52	44	50	50	51	49	49	49
GRAMINEÆ; PER CENT.												
Gramineæ	Anthoxanthum odoratum	4·29	9·06	5·20	6·13	4·09	7·06	6·67	5·47	5·81	5·97	5·89
	Alopecurus pratensis	4·49	5·92	0·32	0·20	3·12	2·62	2·74	0·96	2·73	2·36	2·57
	Phleum pratense	0·01	...	...	...	...	...	...	...	0·01	...	0·01
	Agrostis vulgaris	11·26	9·63	16·14	13·23	9·43	5·55	11·13	13·29	12·26	9·60	10·96
	Aira caryophyllea	0·01	...	0·01	0·04	...	...	0·01	...	0·01	0·01	0·01
	Holcus lanatus	5·04	7·97	3·60	12·55	4·43	5·57	3·81	10·73	7·29	6·63	6·96
	Avena elatior	0·07	0·21	0·13	0·55	0·78	0·67	1·04	0·76	0·11	1·01	0·56
	Avena pubescens	9·65	3·07	3·55	2·89	9·47	5·84	4·35	2·87	4·74	5·81	5·28
	Avena flavescens	2·37	1·95	2·49	1·08	2·25	1·76	2·36	0·85	2·20	1·74	1·97
	Poa pratensis	0·29	0·17	0·09	0·07	0·72	0·63	0·72	0·57	0·15	0·60	0·37
	Poa trivialis	1·54	1·17	0·60	0·24	2·09	1·53	0·91	0·80	0·89	1·58	1·23
	Briza media	1·89	0·68	6·40	7·25	1·37	1·06	4·22	3·72	4·05	2·74	3·40
	Dactylis glomerata	1·76	1·74	0·90	0·70	2·82	2·19	1·50	2·64	1·27	2·54	1·95
	Cynosurus cristatus	0·17	0·13	1·11	0·26	0·49	0·43	0·96	0·44	0·39	0·81	0·70
	Festuca ovina	13·20	13·20	21·67	21·69	7·17	11·59	16·05	20·38	18·01	13·92	15·96
	Festuca pratensis	0·04	...	0·01	0·01	10·11	3·94	2·25	2·27	0·01	4·89	2·45
	Festuca loliacea	...	...	...	0·03	...	...	...	...	0·01	...	0·01
	Bromus mollis	0·13	0·05	0·01	...	0·03	0·04	0·01	0·01	0·05	0·04	0·05
	Lolium perenne	6·37	4·03	2·37	4·55	4·46	3·09	1·91	2·29	4·33	2·94	3·63
	Undetermined (chiefly Gramineæ)	7·84	6·14	2·96	...	9·27	2·00	1·34	...	4·73	3·18	3·70
	Total	70·61	65·53	69·66	71·15	72·44	59·02	63·70	68·33	68·99	65·87	67·43
LEGUMINOSÆ; PER CENT.												
Leguminosæ	Trifolium repens	0·53	0·21	0·38	0·13	0·53	1·85	1·10	0·03	0·31	0·83	0·57
	Trifolium pratense	4·48	2·11	1·88	2·09	2·08	2·87	1·58	2·07	2·39	2·15	2·27
	Lotus corniculatus	1·83	2·35	3·94	3·95	1·84	4·58	2·16	3·29	3·52	3·64	3·53
	Lathyrus pratensis	1·26	0·68	0·96	2·27	1·26	1·49	2·33	2·29	1·32	2·14	1·73
	Total	8·10	5·35	6·96	8·44	6·20	10·79	10·17	7·48	7·74	8·66	8·20
OTHER ORDERS; PER CENT.												
Ranunculaceæ	Ranunculus acris	0·01	0·01	0·07	...	...	0·35	0·04	0·09	0·02	0·12	0·07
	Ranunculus repens et bulbosus	4·98	2·01	2·94	3·45	2·62	1·72	3·22	6·45	3·32	3·50	3·41
Caryophyllaceæ	Stellaria graminea	0·01	0·02	0·02	0·02	0·07	0·42	0·90	0·94	0·02	0·58	0·30
	Stellaria Holostea	...	...	...	...	...	...	...	0·01	...	0·01	0·01
	Cerastium triviale	0·46	0·37	0·85	0·62	0·39	1·02	3·44	0·91	0·62	1·41	1·01
Rosaceæ	Potentilla reptans	...	...	0·01	0·01	0·01	0·01	0·01	0·02	0·01	0·01	0·01
	Potentilla Fragariastrum	...	...	...	...	...	0·01	0·01	0·01	...	0·01	0·01
	Agrimonia Eupatoria	0·01	...	0·02	0·01	...	0·01	0·01	...	0·01	0·01	0·01
	Poterium Sanguisorba	...	0·21	0·49	0·85	...	...	...	...	0·39	...	0·19
Umbelliferæ	Conopodium denudatum	0·97	2·84	2·85	1·90	1·89	0·42	2·17	2·84	2·18	2·00	2·59
	Pimpinella Saxifraga	1·53	3·44	0·26	0·79	0·99	1·20	0·44	0·49	1·65	0·78	1·21
	Heracleum Sphondylium	...	...	0·02	...	...	...	...	...	0·01	...	0·01
Rubiaceæ	Galium verum	...	...	...	...	0·01	0·11	0·01	0·01	...	0·03	0·02
	Galium Aparine	...	...	0·01	...	0·20	0·94	...	...	0·01	...	0·01
Compositæ	Centaurea nigra	0·31	0·59	2·11	1·06	1·20	0·94	3·35	2·47	1·02	1·89	1·50
	Bellis perennis	0·01	0·04	0·01	0·02	...	...	...	0·01	0·02	0·01	0·02
	Achillea Millefolium	1·53	1·16	1·78	1·39	1·13	1·53	3·77	2·81	1·41	2·31	1·86
	Tragopogon pratensis	0·01	...	0·01	0·01	0·20	0·26	0·33	0·01	0·01	0·22	0·13
	Leontodon hispidus	0·06	0·64	1·27	1·22	0·11	0·10	0·13	0·07	0·92	0·10	0·46
	Leontodon autumnalis	...	...	...	...	...	...	...	0·01	...	0·01	0·01
	Taraxacum officinale	0·05	0·16	0·18	0·06	0·12	0·13	0·01	0·14	0·10	0·10	0·10
	Hieracium Pilosella	0·01	0·01	0·02	0·01	...	0·01	0·02	0·01	0·02	0·03	0·02
	Chrysanthemum Leucanthemum	...	...	...	0·12	...	...	...	...	0·03	...	0·01
Dipsaceæ	Scabiosa arvensis	0·01	...	0·02	0·12	0·05	0·01	0·09	0·06	0·04	0·05	0·04
Plantaginaceæ	Plantago lanceolata	7·34	10·73	2·66	2·16	7·74	8·25	0·41	1·43	5·97	4·46	5·21
Scrophulariaceæ	Veronica Chamædrys	0·48	0·32	0·14	0·24	0·20	0·46	0·23	0·57	0·29	0·41	0·35
Labiatæ	Prunella vulgaris	0·01	0·03	0·01	0·09	0·03	0·12	0·01	0·04	0·03	0·05	0·04
	Thymus Serpyllum	0·01	...	...	0·02	...	...	...	...	0·02	...	0·01
	Ajuga reptans	0·01	0·01	...	0·02	...	0·02	0·01	0·01	0·01	0·01	0·01
Primulaceæ	Primula veris	0·01	...	...	0·01	0·03	0·03	0·02	0·02	0·01	0·02	0·02
Polygonaceæ	Rumex Acetosa	1·40	1·76	1·77	1·87	2·02	2·61	2·52	2·06	1·70	2·05	1·87
Liliaceæ	Scilla autans	...	...	...	0·01	...	...	...	...	0·01	...	0·01
Juncaceæ	Luzula campestris	1·91	3·61	3·42	1·77	1·14	2·96	2·98	1·50	2·68	2·14	2·41
Cyperaceæ	Carex præcox	0·19	1·02	0·84	0·37	0·31	1·35	0·90	0·68	0·60	0·81	0·71
Filices	Ophioglossum vulgatum	0·01	...	...	...	...	...	...	...	0·01	...	0·01
Musci	Hypnum squarrosum	0·06	} 0·03	0·01	} 0·06	0·10	} 0·04	0·07	} 0·34	0·05	0·20	0·12
	Hypnum rutabulum	0·01		0·01		0·01		0·01				
	Hypnum blanum	0·01		...		0·01		0·01				
	Total	21·29	29·12	22·36	20·31	21·36	30·19	29·13	24·19	23·27	25·47	24·37

SUMMARY.—PER CENT.

	Plot 3.				Plot 12.				Mean of 1862, 1867, 1872, 1877.		
	1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.	Plot 3.	Plot 12.	Plots 3 and 12.
Gramineæ	70·61	65·53	69·66	71·15	72·44	59·02	63·70	68·33	68·99	65·87	67·43
Leguminosæ	8·10	5·35	6·96	8·54	6·20	10·79	10·17	7·48	7·74	8·66	8·20
Other Orders	21·29	29·12	22·36	20·31	21·36	30·19	26·13	24·19	23·27	25·47	24·37
Total	100·00	100·00	100·02	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE LXIV.—Quantity of each Species, per Acre, in Lbs., Without Manure; Plots 3 and 12.

		Plot 3.				Plot 12.				Means of 1862, 1867, 1872, and 1877.		
		1862.	1867.	1872.	1877.	1862.	1867.	1872.	1877.	Plot 3.	Plot 12.	Plots 3 and 12.
GRAMINEÆ; LBS. PER ACRE.												
	Number of Species	18	15	17	17	16	16	17	16	17	16	17
Gramineæ	Anthoxanthum odoratum	130·6	298·5	83·6	121·0	140·0	232·5	180·2	118·5	158·4	160·5	159·5
	Alopecurus pratensis	137·0	193·9	8·5	7·1	106·8	79·9	61·7	39·8	86·6	67·3	76·9
	Phleum pratense	0·3	...	...	...	...	...	...	...	0·1	...	0·1
	Agrostis vulgaris	346·7	287·5	262·3	313·9	322·8	169·2	229·7	287·8	302·4	227·6	265·1
	Aira cæspitosa	0·2	...	0·2	0·9	...	...	0·2	...	0·4	0·1	0·3
	Holcus lanatus	153·8	265·5	59·2	298·7	158·3	169·2	85·8	219·1	193·8	158·2	176·1
	Avena elatior	2·1	7·0	2·7	1·2	29·7	29·4	41·4	16·4	3·1	29·2	14·6
	Avena pubescens	294·5	102·3	59·4	63·6	530·4	171·9	109·2	62·1	129·7	170·4	150·1
	Avena flavescens	72·4	62·0	57·4	25·5	77·0	53·6	53·6	11·9	54·3	49·0	51·6
	Poa pratensis	8·0	5·7	1·5	1·7	24·0	20·7	16·2	5·8	4·4	16·8	10·6
	Poa trivialis	47·0	39·0	8·2	13·2	91·7	50·8	22·5	17·3	26·9	47·1	37·0
	Briza media	57·7	22·7	105·2	171·4	46·7	50·6	96·0	80·5	89·2	68·2	78·7
	Dactylis glomerata	53·7	58·0	14·8	16·9	96·8	97·2	43·8	57·2	35·8	73·7	54·7
	Cynosurus cristatus	5·2	4·3	18·2	22·2	10·7	12·1	21·6	9·3	12·7	13·2	14·0
	Festuca ovina	405·9	508·5	356·2	517·5	245·6	353·2	361·5	452·0	446·5	353·1	399·8
	Festuca pratensis	1·2	...	0·2	0·2	346·1	120·1	50·7	70·8	0·4	146·9	73·6
	Festuca loliacea	...	...	...	0·7	...	...	...	...	0·2	...	0·1
	Bromus mollis	4·0	1·7	0·2	...	2·7	1·2	0·2	0·2	1·5	1·1	1·3
	Lolium perenne	194·4	134·3	39·0	167·6	152·7	94·2	42·0	49·4	118·8	84·6	101·7
	Undetermined (chiefly Gramineæ)	239·3	204·5	20·7	...	239·5	91·4	20·3	...	122·1	107·0	114·5
	Total	2155·0	2183·4	1128·8	1662·0	2480·3	1799·9	1434·5	1479·3	1787·3	1798·2	1792·7
LEGUMINOSÆ; LBS. PER ACRE.												
	Number of Species	4	4	4	4	4	4	4	4	4	4	4
Leguminosæ	Trifolium repens	18·2	7·0	6·2	3·1	18·1	50·3	24·9	6·6	8·1	22·4	15·2
	Trifolium pratense	126·7	70·3	22·6	49·4	71·3	67·5	20·6	44·8	71·0	51·8	62·4
	Lotus corniculatus	55·9	79·3	97·7	93·4	56·2	129·8	116·1	66·9	81·3	92·3	86·8
	Lathyrus pratensis	38·4	22·7	16·1	54·0	66·6	61·3	82·4	49·6	33·3	57·5	45·4
	Total	247·2	179·3	147·6	201·9	212·3	328·9	229·0	161·9	193·7	223·0	213·4
OTHER ORDERS; LBS. PER ACRE.												
	Number of Species	23	24	29	31	24	30	29	31	28	29	28
Ranunculaceæ	Ranunculus acris	0·3	0·3	1·2	...	...	10·7	0·9	2·0	0·5	3·4	1·9
	Ranunculus repens et bulbosus	148·9	67·0	49·3	61·6	69·7	82·4	72·5	130·7	66·4	88·9	67·6
Caryophyllaceæ	Stellaria graminea	0·3	0·7	0·3	0·5	2·4	12·8	2·3	20·4	0·5	14·0	7·2
	Stellaria Holostea	...	...	...	...	...	...	...	0·2	...	0·1	0·1
	Cerastium triviale	14·1	12·2	14·0	19·4	13·4	30·8	77·5	17·3	14·9	34·8	24·8
Rosaceæ	Potentilla reptans	...	...	0·2	0·2	0·3	0·3	0·2	0·4	0·1	0·3	0·2
	Potentilla Fragariastrum	...	...	...	...	...	0·3	0·2	...	...	0·2	0·1
	Agrimonia Eupatoria	0·3	...	0·3	0·2	...	0·3	0·2	...	0·2	0·1	0·1
	Poterium Sanguisorba	...	1·0	2·0	20·6	...	...	...	...	5·9	...	4·4
Umbelliferæ	Conopodium denudatum	29·6	39·2	46·8	44·9	54·1	165·2	48·3	61·5	54·9	82·4	68·6
	Pimpinella Saxifraga	48·7	114·6	14·1	19·5	33·9	36·6	9·9	10·6	49·5	22·7	36·1
	Heracleum Sphondylium	...	...	0·3	...	...	...	...	...	0·1	...	0·1
Rubiaceæ	Galium verum	...	...	...	...	0·3	2·4	0·2	0·3	...	1·0	0·5
	Galium Aparine	...	...	0·2	...	...	...	...	...	0·1	0·1	0·1
Compositæ	Centaurea nigra	9·5	19·7	34·4	25·1	41·1	29·7	19·5	53·5	22·2	49·8	36·0
	Bellis perennis	0·3	1·3	0·2	0·5	...	...	0·2	0·6	0·1	0·3	0·2
	Achillea Millefolium	46·7	38·7	29·2	47·0	38·7	46·6	84·9	60·8	40·4	67·7	49·0
	Tragopogon pratensis	0·3	...	0·2	0·2	10·3	1·0	1·4	0·2	0·2	7·2	0·3
	Leontodon hispidus	1·9	21·8	20·9	31·2	3·9	3·0	2·9	1·5	19·5	2·3	5·7
	Leontodon autumnalis	...	...	...	...	...	...	...	0·2	...	0·1	0·1
	Taraxacum officinale	1·6	0·4	2·6	1·4	4·1	4·0	0·3	3·0	2·7	2·1	2·9
	Hieracium Pilosella	0·3	0·3	0·2	1·0	...	0·3	0·5	1·7	0·5	0·6	0·3
	Chrysanthemum Leucanthemum	...	...	...	2·6	...	...	...	...	0·7	...	0·3
Dipsaceæ	Scabiosa arvensis	0·3	...	0·3	2·6	1·7	0·3	2·0	1·3	0·8	1·3	1·1
Plantaginaceæ	Plantago lanceolata	224·0	357·5	43·7	74·7	268·0	251·5	9·3	31·0	175·0	139·2	157·1
Scrophulariaceæ	Veronica Chamædrys	14·7	10·7	2·2	5·7	13·4	14·0	6·2	12·4	8·4	11·5	9·9
	Prunella vulgaris	0·3	1·0	0·2	2·1	1·0	3·7	0·2	1·9	0·9	1·9	1·4
Labiatæ	Thymus Serpyllum	...	...	...	2·1	...	...	...	...	0·5	...	0·3
	Ajuga reptans	0·3	0·3	...	0·5	...	0·6	0·2	0·2	0·3	0·2	0·3
Primulaceæ	Primula veris	0·3	...	...	0·5	1·0	0·3	0·7	0·1	0·1	0·6	0·3
Polygonaceæ	Rumex Acetosa	42·7	59·7	29·1	44·2	103·4	110·1	79·3	44·6	43·7	84·5	64·0
Liliaceæ	Scilla nutans	...	...	...	0·2	...	...	...	...	0·1	...	0·1
Juncaceæ	Luzula campestris	58·3	130·3	56·2	41·9	39·0	90·3	67·1	32·5	69·4	57·2	63·1
Cyperaceæ	Carex præcox	5·5	34·0	13·8	8·8	10·9	41·2	20·3	14·7	15·5	21·7	18·6
Filices	Ophioglossum vulgatum	0·3	...	...	...	...	...	...	...	0·1	...	0·1
Musci	Hypnum squarrosum	1·9	1·0	0·2	1·4	3·4	1·2	0·2	12·7	1·3	1·3	1·3
	Hypnum rutabulum	0·3				0·4						0·4
	Hypnum triquetrum	0·3				0·4						0·1
	Total	649·8	970·3	367·6	480·1	731·4	920·2	568·5	522·8	617·0	691·0	654·0

SUMMARY.—QUANTITIES PER ACRE, IN LBS.

Gramineæ	2155·0	2183·4	1128·8	1662·0	2480·3	1799·9	1434·5	1479·3	1787·3	1798·2	1792·7
Leguminosæ	247·2	179·3	147·6	201·9	212·3	328·9	229·0	161·9	193·7	223·0	213·4
Other orders	649·8	970·3	367·6	480·1	731·4	920·2	568·5	522·8	617·0	691·0	654·0
Total	3052·0	3332·0	1644·0	2344·0	3424·0	3049·0	2232·0	2163·0	2598·0	2722·0	2660·0

Number of species.—According to the tables, the total number of species found in the samples from plot 3 was, in the four separation-years respectively—50, 43, 49, and 52; and in those from plot 12—44, 50, 50, and 51. These it is to be understood are the numbers of species found in the samples; but reference to Table XXXVI., pp. 1209–11, will show that generally some were observed on the plots that did not come into the samples, though such occurred in very insignificant amounts. The average number of species over the four years was, on plot 3, 49, on plot 12, 49, and of course on the two plots, also 49.

It is further seen that the number of species of grasses was, on plot 3—18, 15, 17, and 17; and on plot 12—16, 16, 17, and 16; the average number being therefore rather the higher on plot 3. Leguminosæ are uniformly represented by four species in the samples from both plots. The number of species contributed by other Orders were, in the four years, as follows: on plot 3—28, 24, 28, and 31; and on plot 12—24, 30, 29, and 30; the average number being practically the same on the two plots.

It may be said that there is, upon the whole, a slight tendency to an increase in the number of species with the continuance of the unmanured condition; and that such increase as there is, is among the miscellaneous plants. It might indeed have been expected that, as the exhaustion of the soil increased, the competition arising from the luxuriant growth of particular species would have diminished in intensity, and have induced the results observed.

Among the fluctuations from year to year the chief irregularity to be noted is that plot 3 had a large number of species in 1862, and a small number in 1867; whilst plot 12 had a small number in 1862, and a large one in 1867. The reduction in number of species on plot 3 in 1867 was about equally divided between the grasses and the miscellaneous plants; while the increase in number on plot 12 in the same year was entirely in the miscellaneous plants.

The table shows that there was a larger amount of undetermined matter in the earlier than in the later separations, and it is, of course, a question how such matter should be allotted. By careful examination in each case, it has been ascertained that by far the larger amount of the undetermined matter is referable to the grasses, and so, to bring the results of the different years into comparison, it has been thought fairer to include this matter among the gramineous herbage than either to exclude it from the record, or to allot it by judgment merely to the different divisions of Gramineæ, Leguminosæ, and Miscellaneæ. With this explanation we may proceed to consider the results as they stand.

Neither an examination of the tables now under discussion, nor of those including the results of the partial separations in other years, indicates any really marked increase or decrease in the percentage of the grasses in the total mixed herbage on the unmanured plots. There was, however, very considerable fluctuation in the percentage from year to year, according to season. Thus, in the first and the last of the complete separation-years 1862 and 1877, that is with an interval of 15 years, both the

unmanured plots yielded high percentages of Gramineæ. In the second of the four years (1867) they both yielded the lowest, and in the third (1872) about medium percentages.

The percentages of the Leguminosæ also fluctuated from year to year somewhat differently on the two plots, and did so without manifesting any very distinct tendency either to increase or decrease, in relative proportion to the rest of the herbage; though the indications were perhaps the more towards increase with the continuance of the unmanured condition.

Of total Miscellaneæ there was also considerable fluctuation in percentage from year to year, and this was the case on both plots. In the second separation-year (1867), when the percentage of grasses was on both plots the lowest, that of the Miscellaneæ was on both plots the highest; and whilst in the two subsequent separation-years (1872 and 1877), the percentage of Miscellaneæ was on plot 3 fairly uniform, and much the same as in the first year, it was on plot 12 considerably higher than in the first year. On this plot, indeed, there was an obvious tendency to an increase in the proportion of such herbage.

Looking thus at the percentage merely which each of the three main groups has contributed to the herbage each year, it would seem that both the Leguminosæ and the Miscellaneæ, but especially the latter, have rather gained than lost in the competition with the grasses, as the exhaustion has proceeded. But, if we turn from the *percentage* to the *actual* amounts per acre of each description of herbage each year, a clearer idea of what has taken place will be gained. We now observe that each description of herbage—Gramineous, Leguminous or Miscellaneous—has considerably decreased in yield in the later years, and that this is so, though in different degrees, on both plots.

Referring first to plot 3, we find the total produce of the grasses pretty equal in 1862 and in 1867, little more than half as much in 1872, and only about three-fourths as much in the fourth separation-year, 1877, as in the first or second. There is thus, therefore, a manifest reduction in yield of such herbage independently of fluctuation of season. Of leguminous herbage there was much more in the first separation-year than afterwards; but more in the fourth than in either the second or the third; indicating, therefore, a less marked decline in actual yield than in the case of the Gramineæ. The partial separations of later years, indeed, indicate a tendency to increase rather than to decrease.

Lastly, of miscellaneous herbage, plot 3 yielded very fluctuating amounts in the four separation-years: in the second (1867) there was about one-and-a-half time as much as in 1862; in the third (1872) there was little more than half as much as in 1862, and very much less than half as much as in 1867; in the fourth year again (1877) there was very much less actual quantity of such herbage than in either the first or the second year. There was then, as with the grasses, a considerable reduction in the growth of these plants with the progress of the exhaustion, and this reduction of

actual amount grown is much greater in both sets of plants than would be gathered from their percentage relations alone.

Turning to plot 12, the reduction in the actual yield of the grasses is seen to be very considerable. It is also more uniform from the first to the third separation-year than on plot 3, and the amount is much the same in the fourth as in the third, and only about three-fifths as much as in the first. Of leguminous herbage there was, on the average, more yielded on plot 12 than on plot 3. The fluctuations in amount from year to year were great, and not accordant in order with those on plot 3. Of miscellaneous herbage, again, there was, on the average, more on plot 12 than on plot 3, and there were also considerable fluctuations from year to year; but these were not so discordant in their order with those on plot 3, as in the case of the Leguminosæ. On both plots there was a considerable increase in the amount of miscellaneous herbage in the second year compared with the first, and on both there was much less in the third and fourth than in the first year. In the last two separation-years there was more on plot 12 than on plot 3.

The general result is, then, that on both plots there was a tendency to considerable reduction in the amount of both the Gramineæ and the Miscellaneæ in the later years, with less marked, if any, reduction in the much smaller actual quantity of leguminous herbage. The resultant is a considerable reduction in the yield of the total mixed herbage.

It is obvious that, considering the fluctuations from year to year according to season, the results obtained in four individual years at stated intervals might be misleading in considering whether there has or has not been a real increase or decrease in the growth with the continuance of the unmanured condition. But it may be here remarked that the decided indications of decrease in growth manifested in the tables under consideration are fully confirmed by the amounts of produce of hay, of nitrogen, and of mineral matter, obtained in each of the first 20 years of the experiments (see Part I., p. 300, and context).

It will be observed that the actual quantities yielded are, on the average, considerably greater on plot 12 than on plot 3, and, as has been pointed out at p. 301, Part I., there is reason to believe that the soil of, at any rate, a part of plot 12 was "made ground," which had a greater depth of mould than in the case of the plots generally. For this reason the results obtained on plot 3, instead of the mean results of the two unmanured plots, will be taken as the standard by which to compare those obtained on the manured land.

We now turn to the percentage, and the actual amounts, of the different species occurring on the two plots. It must be remembered that the first year of complete separation (1862) was the seventh year of the experiments, and hence the distribution of plants then found cannot be taken as indicating the exact state of the flora at the commencement of the experiments. At the same time it must be borne in mind that

whatever changes have occurred on these two plots have been the results of natural, not artificially induced, conditions.

Unfortunately, we have but little evidence as to the changes that occurred during those first seven years. As already alluded to, the first attempts at really quantitative botanical separation were made in the third year of the experiments (1858), but neither were the samples taken with so much care, nor were the botanical separations conducted with as much knowledge and experience, then as subsequently; perhaps, therefore, it will be sufficient to remark in regard to the results of the preliminary separations, that they showed *Lolium perenne* to be then the most prominent grass on the unmanured plot 3; *Holcus lanatus* was second, yielding a very high proportion; whilst the only other grasses that were at all prominent were *Avena elatior*, *Anthoxanthum odoratum*, *Agrostis vulgaris*, *Briza media*, and *Festuca ovina*, which were so somewhat in the order in which they are here mentioned.

Reference to Table LXIII., p. 1294, will show that the order of prevalence was very different from this in each of the four complete separation-years. *Lolium perenne* is shown to be in very much smaller amount than the earlier separation indicated; but with, notwithstanding some irregularity, a tendency to still further reduction in amount, thus confirming the conclusion of its former greater prominence. *Holcus lanatus* is also in each of the subsequent separations very much less prominent than was indicated in 1858, though on both plots it was more prominent in the last of the four than in either of the preceding separation-years. *Avena elatior*, too, has gone down very considerably. On the other hand, compared with 1858, *Anthoxanthum odoratum* has, in the subsequent years, maintained its position, or has even increased in amount on the unmanured plots. *Agrostis vulgaris* has done so in a very marked degree, as also has *Briza media*.

Turning from the comparison of the more recent and more detailed results with the initiative ones of 1858, and confining attention to those of the four complete separation-years alone, the marked features of condition and change may be described as follows:—

The most prominent plant on both plots, and the one which has increased in greatest degree (both in percentage and in actual quantity) with the continuous unmanured condition, is the hardy, waste-land grass, *Festuca ovina*. This grass has acquired a greater degree of prominence on the poorer plot 3 than on the better-conditioned plot 12.

The plant second in order in prominence, and again on both plots, is the creeping, self-asserting, *Agrostis vulgaris*, and again it has been the more prominent on the poorer plot 3.

Holcus lanatus, though fluctuating considerably in proportion from year to year, is also doubtless again taking a prominent place.

Next in order comes *Anthoxanthum odoratum*, which, though variable in amount from year to year, is rather on the increase than on the decrease, in proportion to its

associates, but, with the decreasing total herbage somewhat on the decrease in actual quantity per acre.

Briza media, though yielding a less average amount than *Anthoxanthum*, is nevertheless obviously on the increase, both in percentage and in actual quantity. *Avena pubescens* has contributed a considerable average percentage proportion and actual amount on both plots, but on both it has greatly decreased from the first to the fourth separation-year. And only now comes in order, and as already observed upon the whole decreasing both in percentage and in actual amount, *Lolium perenne*, which it will be remembered was the most prominent grass in the examination made in the third year of the experiments (1858). The other grasses, which showed moderate prominence in the earlier separations, but which have declined considerably in the later, under the unmanured condition, are the more valued and freer-growing grasses, *Alopecurus pratensis*, *Avena flavescens*, *Poa trivialis*, and *Dactylis glomerata*.

Looking at the mean results of the four years for each of the two plots, as given in the first two columns in the right-hand division of each of the two tables, it will be observed that the grasses which are in higher average proportion, and actual amount, on the more exhausted plot 3 are *Festuca ovina*, *Agrostis vulgaris*, *Holcus lanatus*, *Briza media*, and *Lolium perenne;* whereas those which are more prominent on the better-conditioned plot 12 are *Avena pubescens*, *Dactylis glomerata*, and *Poa trivialis;* the poorer grasses obviously the more prevailing on the poorer plot.

On reference to the tables, it cannot fail to be observed that, upon the whole, there is surprising general uniformity in the components of the herbage on the duplicate unmanured plots; and the differences which have been referred to, connected as they obviously are with some differences in the conditions of the land, are a confirmation of the trustworthiness of the results rather than otherwise.

One remarkable discrepancy between the herbage of the two plots remains, however, to be mentioned, viz.: that on the poorer plot 3, scarcely a trace of *Festuca pratensis* was observed at either separation; whilst on plot 12 there was 10 per cent. of it in the first, and more than 3 per cent. in the fourth, separation-year. Its very prominent occurrence on plot 12 in the earlier years must doubtless have been due to some accidental circumstance, probably connected with the somewhat abnormal condition of the land before referred to; but, with the continuous exhaustion, it would seem to be rapidly disappearing.

As already said, of leguminous species four only have been found in the samples from the unmanured plots, viz.: *Trifolium repens*, *T. pratense*, *Lotus corniculatus*, and *Lathyrus pratensis*. In the third year of the experiments, 1858, the most prominent of these was *Lathyrus pratensis*, *Lotus corniculatus* coming second, and *Trifolium pratense* third.

Trifolium repens has occurred in insignificant proportion and amount on both plots in the more complete separations; irregularly in the different years, becoming gradually

reduced on plot 3; increasing in the second and third years on plot 12, but going down to less in the fourth year, however, than on plot 3.

Trifolium pratense has, in each year, and on each plot, occurred in considerably larger amount than *T. repens*, still the quantity of it has been small on both plots; decreasing almost regularly on plot 3, but less so on plot 12.

The only leguminous plant which has, in a marked degree, gained ground on the unmanured plots is the deep-rooting, drought-resisting *Lotus corniculatus*; and although not without exception in this respect, it has, perhaps, increased with more regular progression, though occurring in less average amount, on the poorer plot 3 than on the less exhausted plot 12.

Lastly, *Lathyrus pratensis* has yielded a fluctuating but considerably smaller percentage and actual amount than *Lotus corniculatus*. It will be seen further on that this plant is very dependent upon superficial supply of certain constituents; and, in accordance with this, we find the percentage, and the yield of it, the higher on the richer of the two plots, 12.

Thus, of the leguminous plants occurring on the unmanured plots, the only one which has improved its position in the struggle is *Lotus corniculatus*; which has a deeply-penetrating, thick, fleshy root, by virtue of which it must be supposed that it is less dependent on the superficial layers of the soil for either food or moisture, and is able to store up material so as the better to withstand drought or exhaustion of the surface-soil. By these means it maintains its position when many of its associates fail.

In the early separation, in 1858, *Plantago lanceolata* was by far the most prominent of the miscellaneous plants on the unmanured plots, where it contributed nearly 11 per cent. of the mixed herbage. No other species yielded 2 per cent., and those which were at all prominent at that time were so in the following order: *Conopodium denudatum*, *Achillea Millefolium*, *Rumex Acetosa* (*Lychnis Flos-cuculi**), and various species of *Ranunculus*. The more recent and more complete separations show that in most cases there is very great irregularity in the occurrence of the different miscellaneous species from year to year, dependent on the characters of the seasons, and doubtless on the degree of intensity of the competition engendered accordingly. Without manure, *Plantago lanceolata* may still be considered the most prominent weed, at any rate on the poorer of the two unmanured plots (3); but on both plots it was in considerably less amount in the two later, than in the two earlier separations. The plants which, in proportion to the total herbage, have shown the most marked tendency to increase under the conditions of exhaustion are the several species of *Ranunculus*, and next, perhaps, in this respect, comes the undesirable, and poverty-indicating, *Luzula campestris*. In less and very variable proportions and amounts, but still in some seasons very prominent, and some of them increasing, are *Conopodium denudatum*, *Pimpinella*

* This, though not included in any sample, is said to have been found on this plot in 1858, but has never been seen since, although it occurs in a plantation within 100 yards of the plot.

Saxifraga, *Achillea Millefolium*, *Centaurea nigra*, and *Rumex Acetosa*. In insignificant amounts, but still in most seasons present and notable, are *Cerastium triviale*, *Poterium Sanguisorba* (on plot 3), *Leontodon hispidus*, *Veronica Chamædrys*, and *Carex præcox*. The remainder of the miscellaneous species occur less regularly, and in still smaller proportions, as will be seen by an examination of the tables.

Comparing the mean results for each plot, it may be noted that *Plantago lanceolata*, *Luzula campestris*, *Pimpinella Saxifraga*, and *Leontodon hispidus* are, on the average, more prominent on the poorer plot 3, whilst *Conopodium denudatum*, *Rumex Acetosa*, *Achillea Millefolium*, *Centaurea nigra*, and *Cerastium triviale* are the more prevalent on the plot 12.

Referring now, not to the prevalence of individual species, but of the species collectively of different families, it is seen that *Plantaginaceæ* have, on the average of the two plots, yielded the largest both percentage and acreage amounts among the miscellaneous plants. The *Umbelliferæ* and *Compositæ* came second and third, the *Ranunculaceæ* fourth, and, after these, *Polygonaceæ* and *Juncaceæ*. Comparing the two plots, the *Plantaginaceæ* are decidedly the more prominent on the poorer plot 3; whilst the *Compositæ* and the *Polygonaceæ* are so on the less exhausted plot 12.

Upon the whole it may be said that there is a tendency to increase in the number of species on the unmanured plots; and the greater the exhaustion, the less will the grasses, and the more will the Leguminosæ, but especially the miscellaneous plants, predominate. Among the latter, those which become the more prominent are referable to families noteworthy for the large numerical proportion in which either their specific or their individual representatives occur in temperate climates, under natural conditions; that is in the absence of stimulated luxuriance and consequent intensified struggle. Thus, of the widely distributed families, we have nine species of *Compositæ*, three of *Umbelliferæ*, four of *Rosaceæ*, four of *Ranunculaceæ*, and three of *Labiatæ*; whilst some of the smaller families, which have fewer species, are remarkable for the large quantity yielded by their individual representatives, as *Polygonaceæ* and *Juncaceæ*.

Natural rotation.—Having now considered the climatal conditions of the four separation-years, the characteristics of the chief species found on the various plots, and in detail the number, percentages, and actual weights, of the species occurring on the unmanured plots, we are in a position to appreciate the facts in reference to what has been called natural alternation or rotation, as a result of the struggle uninfluenced by the artificial conditions induced by manuring.

The conditions of success are so variable, even for the same plant at different stages of growth, and in different seasons, that we can scarcely predicate with any certainty whether any individual species will gain or lose in the conflict; although we may, perhaps, form a fair conclusion as to the prevalence of certain groups of species: as, for instance, the poorer grasses—one or other of them according to the wetness or dryness of the season or series of seasons, and also according to the decline of the freer-

growing competitors. It is not, however, safe to assume that the intrinsically strongest, the hardiest, or the most prolific, whether in seed or offshoot, will, in virtue of any one of these endowments, necessarily be the victor under all circumstances. The factors are so numerous, so complex, and so interdependent, that the "survival of the fittest" depends not on any one quality, but on a capacity for adaptation to a combination of conditions some favourable, others detrimental.

The idea of a natural alternation, or rotation, as broached by M. Dureau de Lamalle (previously referred to at p. 1212), is not strictly applicable to the case before us. That there is some such alternation is evident. It is not, however, the regular rhythmic process assumed by M. Dureau, but a phenomenon influenced by the many varying circumstances to which reference has been made, and it is, therefore, in itself very variable.* It is to be borne in mind that in the Rothamsted experiments, even in the case of the unmanured plots, there are some artificial conditions introduced. Thus, the cutting of the crops interferes with the normal course of the vegetation, whilst the removal of them from the land induces a gradual exhaustion. Further, the variations of season from year to year will have their varied effect, accordingly as the condition of the herbage is affected by such artificial treatment. It fact, it will be seen that variations of season have a most potent influence on the result, not only under the less artificial conditions of the unmanured, but also under the more artificial ones of the manured plots.

In most cases we are without data for ascertaining the duration of life of a perennial plant, especially when it is subjected to cutting; but we know that there is a limit, and that, when this is reached, one plant will die, and another will take its place; and so we may have a fluctuating relative predominance of Gramineæ, of Leguminosæ, or representatives of other families.

The Manured Plots.

We now come to discuss the results due to the increased luxuriance induced by characteristically different conditions of manuring. We must refer to Part I., pp. 293–300, for the previous history and general character of the area selected for experiment, for the arrangement of the plots, for the detailed description of the manures employed, the mode of their application, &c. At p. 300, *et seq.*, will be found a discussion of the results obtained on each individual plot, so far as the amounts of total produce, of nitrogen, and of mineral matter yielded, are concerned; and it will be convenient now to consider the *botanical* results obtained on the different plots, in the same order as to plots as in discussing the so-designated *agricultural* results.

It is, therefore, proposed to consider the effects produced by ammonia-salts alone; nitrate of soda alone; mixed mineral manure alone (including potass); superphosphate

* The remarks of Mr. Darwin, on the "struggle for existence," chapter 3 of the 'Origin of Species,' should be consulted with reference to the points raised in this section.

of lime alone; mixed mineral manure (without potass); ammonia-salts, in various amounts, with mixed mineral manure (including potass); nitrate of soda, in different quantities, with mixed mineral manure (including potass); ammonia-salts and superphosphate of lime; ammonia-salts and mixed mineral manure (with and without potass); ammonia-salts alone (13 years), succeeded by mixed mineral manure; equal nitrogen and equal potass, in nitrate of soda and sulphate of potass, and in nitrate of potass, in each case with superphosphate of lime; mixture supplying the ash constituents, and the nitrogen, of one ton of hay; and, lastly, farmyard manure alone, and with ammonia-salts in addition.

The Tables.—The plan adopted is—referring to Tables X. and XI. in the Appendix for full particulars of the occurrence of each species, however small in amount, in each separation-year, on each plot—to embody with the text relating to each plot a table, showing, in the case of the grasses and of the Miscellaneæ, the full details for those species which have exceeded 1 per cent. of the total herbage in any one of the separation-years; for those species which have occurred in less amount than 1 per cent. (bracketed together) the collective result only; and, lastly, a simple enumeration of all those which, though they occurred on the unmanured plot 3, were not found at all in any of the samples from the manured plot to which the table refers. This plan reduces the record in the tables with the text, and facilitates their study. In the case of the Leguminosæ, the species of which are few, but of which the occurrence or absence is always important, the results are given in full detail. For each plot the particulars given are—1, the percentage of each species, or group of species, in the total mixed herbage; 2, the produce per acre, in lbs., of each species or group of species; 3, the increase or the decrease in the actual amounts of each species, or group of species, on the manured plot under consideration, compared with the amounts on the unmanured plot 3, as given in Table LXIII., p. 1294.

With reference to this arrangement of the results in the tables, followed also in the discussion of them, it should be clearly recognised that, comparing plot with plot, the percentages of the different species, and the actual amounts of them per acre, may represent very different relations. Thus, supposing any particular species contributed 5 per cent. to the total mixed herbage of a plot yielding say only 2,000 lbs. of total produce per acre, this would represent the growth of only 100 lbs. per acre of that species on that plot. Supposing, however, the same species contributed only the same percentage (5) to the herbage of a plot yielding say 6,000 lbs. of total produce per acre, this would represent the growth of 300 lbs. instead of only 100 lbs. of that species on the same area. Or, to put the converse case, supposing a species contributed 300 lbs. to a total produce of 2,000 lbs., this would represent 15 per cent. of that species; but supposing the same species contributed the same amount, 300 lbs. per acre, to a total produce of 6,000 lbs., the identical amount of actual yield would only represent on that plot 5, instead of 15 per cent., of the total produce. Again, the increase or the decrease in the actual yield of the different species compared with

their amount on the unmanured, or on any other plot, being the resultant of the actual amounts on two different plots, may show quite different relations between one species and another, from those indicated either in the columns of percentage, or in those of actual amount. These distinctions should be borne in mind; otherwise, illustrations drawn from the tables may be taken to be repetitions which are in reality not such.

2. *Ammonia-salts, alone; Plot* 5.

On this plot 400 lbs. of ammonia-salts have been applied per acre, per annum, each year, from 1856 up to the present time. Formerly (and in Part I.) we estimated that this amount of the ammonia salts supplied about 82 lbs. of nitrogen; but of late years they have occurred in commerce in a state of greater purity, and the quantity of nitrogen now supplied may be 88 lbs., or probably for the whole period 86 lbs.

It is obvious that, under the condition of this experiment, any increased growth would be dependent for its necessary mineral constituents (sulphuric acid and chlorine excepted) on the supplies derived from the soil itself. The result has been a rapidly-decreasing amount of produce, and of increase over that without manure, in the later as compared with the earlier years. The details show that there was also a reduced amount of mineral matter taken up in the later years. Indeed, in the later years there has been actually less of some important mineral constituents taken up than on the unmanured plot, 3.

Table LXV., p. 1306, shows the botanical composition of the herbage of plot 5;—the percentage, and the actual amount per acre, of the different species and groups, and the increase or deficiency of each compared with the unmanured plot, 3.

The change in the flora of this plot (5), under the influence of a relative plethora of nitrogen, and exhaustion of available mineral constituents, has been very great.

Unfortunately, the evidence available relating to the period of the experiments prior to the first complete separation-year (1862) is not such as to enable us to speak as definitely as might be desired as to the relative predominance of grasses, Leguminosæ, and Miscellaneæ, during that period. Starting from 1862, the table shows, in the main, a very great increase in the percentage of the grasses, a very small amount of, and an immaterial change in, the Leguminosæ, and on the whole a very great reduction in the percentage proportion, and especially in the actual amount, of miscellaneous species. The second separation-year was, however, a very marked exception in these respects. In that year, the grasses were in unusually small, and the Miscellaneæ in unusually large, proportion. The autumn, winter, and spring had been very changeable, whereby early vegetation was much checked; the usual maturing period was also very changeable. The consequent restricted growth of the grasses was, of course, an element in favour of such Miscellaneæ as could take advantage of the climatal and manurial conditions. The percentage of total grasses was, in 1862 rather more than 86, in 1867 not quite 72, in 1872 nearly 85, and in 1877 more than 94. In neither year did the Leguminosæ contribute ½ per cent. But the Miscellaneæ gave less than 14 per cent. in 1862; more than double, or nearly 28 per cent., in 1867; less than 15 per cent. in 1872; and less than 6 per cent. in 1877.

Table LXV.—Number of Species, Percentage, Quantity per Acre, &c.,

	Number of species, and proportion per cent.				
	1862.	1867.	1872.	1877.	Mean.
Number of Species.					
Gramineæ	17	15	15	13	15
Leguminosæ	4	4	3	2	3
Other Orders	17	17	13	14	15
Total	38	36	31	29	33
Gramineæ.	p. c.	p. c.	p. c.	p. c.	p. c.
Anthoxanthum odoratum	5·77	5·51	3·04	4·09	4·60
Agrostis vulgaris	24·30	20·97	28·62	29·46	25·34
Holcus lanatus	10·06	8·15	1·90	3·01	5·03
Avena elatior	3·93	2·78	1·49	0·23	2·11
Avena pubescens	7·31	0·62	0·24	0·12	2·07
Poa pratensis	1·97	0·65	0·61	0·23	0·84
Dactylis glomerata	2·39	1·39	0·70	3·25	1·93
Festuca ovina	21·99	30·57	46·56	53·21	38·11
Lolium perenne	3·33	1·21	0·97	0·09	1·40
None yielding 1 per cent. (Alopecurus pratensis, Aira cæspitosa, Avena flavescens, Poa trivialis, Briza media, Cynosurus cristatus, Festuca pratensis, Bromus mollis)	2·70	1·38	1·62	0·27	1·50
Absent—Phleum pratense, Festuca loliacea	...	...	...	...	...
Undetermined (chiefly Gramineæ)	3·45	1·61	0·95	...	1·50
Total	86·32	71·85	84·70	94·08	84·23
Leguminosæ.					
Trifolium repens	0·01	0·01	0·01	...	0·01
Trifolium pratense	0·04	0·01	...	...	0·01
Lotus corniculatus	0·06	0·31	0·41	0·14	0·23
Lathyrus pratensis	0·02	0·01	0·04	0·05	0·03
Total	0·12	0·34	0·46	0·19	0·28
Other Orders.					
Conopodium denudatum	1·15	5·74	1·02	0·65	2·14
Galium verum	...	0·61	2·40	0·22	0·81
Scabiosa arvensis	0·63	0·29	0·62	1·87	0·85
Centaurea nigra	0·01	2·43	2·18	0·83	1·29
Achillea Millefolium	1·33	1·09	1·06	0·18	0·91
Rumex Acetosa	9·15	10·94	7·13	2·13	8·59
Luzula campestris	1·11	0·22	0·15	0·06	0·48
None yielding 1 per cent. (Ranunculus acris, R. repens et bulbosus, Stellaria graminea, Cerastium triviale, Spiræa Ulmaria, Pimpinella Saxifraga, Heracleum Sphondylium, Galium Aparine, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triquetrum)	0·78	1·10	0·29	0·33	0·63
Absent—Potentilla reptans, Poterium Sanguisorba, Agrimonia Eupatoria, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium sphondylium, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Scilla nutans, Ophioglossum vulgatum	...	...	...	...	...
Total	13·56	27·81	14·84	5·75	15·49
Summary.					
Gramineæ	86·32	71·85	84·70	94·08	84·23
Leguminosæ	0·12	0·34	0·46	0·19	0·28
Other Orders	13·56	27·81	14·84	5·75	15·49
Total	100·00	100·00	100·00	100·00	100·00

of each Species, by 400 lbs. Ammonia-salts alone; Plot 5.

Quantity per acre.					Increase + or decrease − compared with plot 3, without manure.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
...	...	...	...	...	− 1	0	− 2	− 4	− 2
...	...	...	...	...	0	0	− 1	− 2	− 1
...	...	...	...	...	−11	−7	−15	−17	−13
...	...	...	...	...	−12	−7	−18	−23	−16
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
222·4	182·2	76·4	129·7	150·4	+ 91·8	−108·3	− 9·1	− 0·3	− 4·0
686·5	693·3	669·2	869·7	792·2	+ 580·8	+468·2	+ 433·9	+ 555·3	+489·8
280·5	170·3	47·7	91·9	173·8	+ 234·7	− 86·2	− 11·5	− 207·9	− 20·0
151·4	91·9	37·4	4·3	71·9	+ 149·3	+ 84·9	+ 30·2	+ 5·6	+ 68·8
261·7	20·8	6·0	2·5	78·0	− 12·5	− 81·5	− 52·4	− 60·1	− 51·7
41·2	21·5	13·3	9·4	21·2	+ 32·3	+ 19·6	+ 13·5	+ 8·1	+ 16·8
32·1	46·0	17·6	30·9	42·9	+ 39·4	− 12·0	+ 2·3	+ 29·2	+ 17·1
847·5	1610·6	1176·5	1573·7	1150·6	+ 441·8	+804·1	+ 814·3	+1056·2	+704·0
129·3	40·9	24·3	2·7	49·8	− 68·1	− 94·3	− 14·7	− 104·9	− 70·0
104·2	45·5	41·1	9·0	49·8	− 220·6	−279·1	− 157·0	− 233·6	−222·1
...	...	...	...	...	− 0·3	...	...	− 0·7	− 0·3
133·0	53·3	23·8	...	52·3	− 106·3	−151·2	− 34·9	...	− 70·6
3226·9	2375·4	2129·3	2776·7	2652·1	+1171·8	+192·0	+1000·5	+1094·7	+864·7
Leguminosæ (continued).									
0·4	0·3	0·3	...	0·3	− 13·8	− 6·7	− 3·9	− 3·1	− 7·6
1·5	0·3	...	...	0·4	− 13·3	− 70·0	+ 27·6	− 49·4	− 70·3
1·9	10·3	10·3	4·1	6·7	− 84·0	− 68·0	+ 87·4	− 92·3	− 74·9
0·3	0·3	1·0	1·5	0·9	− 37·6	− 22·4	− 13·1	− 54·5	− 32·4
4·6	11·2	11·6	5·6	8·3	− 242·6	−167·1	− 138·0	− 199·3	−180·4
Other Orders (continued).									
44·3	180·7	23·6	12·3	69·7	+ 14·7	+ 91·4	− 21·2	− 29·7	+ 14·9
...	20·2	60·3	6·5	21·6	...	+ 20·2	+ 60·3	+ 6·5	+ 21·6
1·2	9·3	13·6	49·3	18·3	+ 0·9	+ 9·3	+ 13·3	+ 48·5	+ 18·0
0·4	80·3	54·3	13·6	37·7	− 9·1	+ 80·3	+ 20·2	− 9·3	+ 18·3
51·2	30·0	28·4	4·7	29·5	+ 4·5	− 2·7	− 2·9	− 42·3	− 17·9
332·6	527·0	179·2	62·9	280·4	+ 309·9	+488·3	+ 150·1	+ 197	+230·7
45·9	30·9	9·8	1·3	17·2	− 18·9	− 29·8	− 32·4	− 60·6	− 51·9
30·1	36·4	7·4	9·7	21·3	− 428·6	−387·0	− 133·7	− 202·6	−332·9
...	...	...	...	...	− 4·0	− 31·3	− 30·2	− 62·0	− 32·0
522·6	919·4	373·1	169·7	496·2	− 127·2	− 50·9	+ 8·5	− 319·4	−121·2
Summary (continued).									
3226·9	2375·4	2129·3	2776·7	2652·1	+1171·8	+192·0	+1000·5	+1094·7	+864·7
4·6	11·2	11·6	5·6	8·3	− 242·6	−167·1	− 138·0	− 199·3	−180·4
522·6	919·4	373·1	169·7	496·2	− 127·2	− 50·9	+ 8·5	− 319·4	−121·2
3753	3306	2514	2952	3157	+ 802	− 26	+ 865	+ 576	+550

It will thus be seen that the botany of the plot has varied exceedingly at the different periods. In addition to the influence of the manure, this has been due in part to the character of the intermediate seasons, and of their vegetation, and in part to the characters of the seasons of growth themselves. In further illustration of this, it will be observed that, whilst there was a reduction in the total weight of gramineous herbage per acre from the first to the third separation-year, there was much more than the average weight of such herbage in the fourth. With regard to the Miscellaneæ again, whilst the first of the four years gave more than 500 lbs., the second contributed more than 900 lbs., the third less than 400 lbs., and the fourth less than 170 lbs.

Notwithstanding these great fluctuations in the general characters of the herbage according to season, an examination of the details relating to the proportion, and the amount, of the individual species, not only further illustrates the point, but shows clearly a progressive change referable to the condition of manuring.

It may here be premised that, according to the separations of 1858, *Lolium perenne* and *Holcus lanatus* were then very prominent grasses, *Festuca ovina* being about equally abundant; *Agrostis vulgaris*, *Dactylis glomerata*, and *Avena elatior* were also prominent, but in a less degree. Perhaps the most characteristic feature is the very great increase in the percentage of *Festuca ovina*, and notwithstanding the reduced amount of total produce, a gradually increasing quantity per acre of this individual poor grass from year to year. The percentage has increased from under 22 in the first, to more than 53 in the fourth separation-year; and the produce of it per acre from under 850 lbs. in 1862, to nearly 1,600 lbs. in 1877.

Next in order of prominence is *Agrostis vulgaris*, which, excepting in the second year (1867), and in a much less degree than *Festuca ovina*, has also gradually increased in percentage proportion; but which, with diminishing yield of total produce per acre on the plot, has not itself given an uniformly increased actual amount in the later years.

With the exception of these two inferior grasses, the *Festuca* maintaining itself in competition better under dry, and the *Agrostis* under wet conditions, every other grass, and it may also be said every other plant, has diminished, both in percentage, and amount per acre, under the peculiar conditions of manuring of this plot. *Holcus lanatus*, one of the most prominent of the grasses in 1858, has gone down from about 10 per cent. in the first, to only about 3 per cent. in the fourth separation-year; *Avena pubescens* from more than 7 to a fraction of 1 per cent.; *Avena elatior* from nearly 4, also to a fraction of 1 per cent.; and *Lolium perenne*, which was first in order of prominence in 1858, has gone down from more than 3 per cent. to practically nothing in the last separation-year. *Anthoxanthum odoratum* has also declined, but in a less degree; whilst *Dactylis glomerata*, which was in each of the four years in comparatively small amount, had somewhat gained ground in the fourth. The decrease in the actual yield per acre of these grasses is more marked than is that of

their percentage. For example, *Holcus lanatus* has gone down from a yield of nearly 400 lbs. to less than 90 lbs. per acre.; *Avena pubescens* from nearly 300 lbs. to little more than 3 lbs.; *Avena elatior* from more than 150 lbs. to less than 7 lbs.; and *Lolium perenne* from nearly 130 lbs. to less than 3 lbs.; whilst even *Anthoxanthum odoratum* is reduced in amount from 222 lbs. per acre in 1862, to scarcely 121 lbs. in 1877; and *Dactylis glomerata*, though yielding rather more in the fourth than in the first separation-year, has in neither case contributed 100 lbs.

Of the four Leguminosæ, not one is in any degree prominent; but it is noteworthy that the only one which has shown any appreciable tendency to increase is the deep-rooting, self-dependent, *Lotus corniculatus*.

Of Miscellaneous species, the only one in any prominence is *Rumex Acetosa;* but, excepting that it was in much larger proportion and amount in the second separation-year (1867) than in the first, it also has in the main much declined, yielding more than 9 per cent. in the first, and little more than 2 per cent. in the fourth separation-year; and, in actual weight, more than 350 lbs. per acre in the first, and scarcely 63 lbs. in the fourth separation-year. *Achillea Millefolium* has declined from 1·33 in the first, to 0·16 in the fourth year, and *Luzula campestris* from more than 1 to a very small fraction. *Conopodium denudatum* was in small proportion, and amount, and also declining, though, as in the case of *Rumex Acetosa*, it increased remarkably in the second separation-year (1867), when, from the characters of the season, the growth of the Gramineæ was so restricted. The only miscellaneous species which uniformly increased, though still occurring in insignificant amount, was *Scabiosa arvensis*.

The table shows that a large number of miscellaneous species, which occurred in moderate amounts on the unmanured plot, did not collectively contribute 1 per cent. to the herbage of this plot, and about an equal number were not represented at all.

Compared with the produce without manure, the columns on the right-hand of the table show that, taking the average of the four years, there was an increase of about 865 lbs. per acre per annum of gramineous herbage; more than this amount in the first, third, and fourth years, but less than one-fourth as much in the second separation-year. In each of the four years there was actually less leguminous herbage, and on the average 185 lbs. less on the manured plot, 5, than on the unmanured plot, 3. That is to say, the leguminous species, which are characterised by containing a very high percentage of nitrogen, developed and yielded actually less under the influence of highly nitrogenous manure than they did without manure continuously.

Of the collective miscellaneous herbage again, the members of which are also generally richer in nitrogen than the Gramineæ, there was each year, with one slight exception, less on this manured plot than on the unmanured one; and, taking the average of the four years, there was 121 lbs. less. The actual quantity of *Rumex Acetosa* was, however, considerably more on the manured plot, and that of some other species slightly more; but the balance against the manured plot was due to a large number of species that were represented on the unmanured plot occurring either

not at all, or in very small quantity, on the manured one. Among those which were comparatively prominent on the unmanured, but which were scarcely represented on the manured plot, 5, *Plantago lanceolata* especially, and the several species of *Ranunculus*, may be noted.

Upon the whole, the result of the annual application of a relative excess of ammonia-salts, without mineral or ash-constituents, the plants having thus to rely exclusively on the resources of the soil for these, is greatly to reduce the total number of species, especially of the Miscellaneæ, and to reduce the actual quantity grown, not only of the collective Miscellaneæ, but of every individual species occurring in any degree of prominence. Leguminosæ are almost banished; and although the number of species of grasses occurring in greater or less amount is nearly the same as without manure, by far the larger proportion of the whole produce consists of two grasses only—*Festuca ovina* and *Agrostis vulgaris*. These two have increased in both proportion and amount, whilst all others have diminished in a greater or less degree; and of these two, which have increased, the poorer *Festuca ovina*, has done so in by far the larger proportion, contributing in the fourth separation-year more than half the total produce, whilst *Agrostis vulgaris* supplied nearly 30 per cent. of it.

Thus, with a supply of nitrogen in the form of ammonia-salts, in which it distributes in an available condition much less rapidly and widely than when applied as nitrate of soda, the herbage has come to consist almost exclusively of a very few comparatively superficially rooting species, and the result was, as has been already referred to, and as will be illustrated in detail in Part III., that the collective herbage was able to take up even less of some of the mineral constituents in the later years than that without manure, which comprised a very much more uniform mixture of a large number of species, of varying habits of growth, and of varying range of food collection.

3. *Nitrate of soda, alone; Plots* 15 *and* 17.

The application of nitrate of soda did not commence until the third year of the experiments (1858). For 18 consecutive years, 1858 to 1875 inclusive, plot 15 received 550 lbs. of nitrate of soda per acre per annum, estimated to contain the same amount of nitrogen (about 86 lbs.) as the ammonia-salts applied to plot 5. Over the same period of 18 years, plot 17 received half the amount of nitrate, as it was then found that, with the larger amount of nitrate, there was scarcely any more increase than with the smaller, and that the proportion of the nitrogen supplied which was recovered in the increase of crop was much less where the larger amount was used; the application of nitrate to that plot was discontinued after 1875, the eighteenth year, and in, and since, 1876, a mixed mineral manure, including potass, has been applied instead. The object of this was, first, to determine whether or not, under these circumstances, any material proportion of the hitherto unrecovered supplied nitrogen would now be recovered; and, secondly, to ascertain how far the character of the vegetation in

regard to the distribution of species would revert to its former condition. Thus, the fourth separation-year (1877) is the second year of the application of the mineral manure instead of the nitrate on plot 15. On plot 17, however, where the smaller quantity of nitrate was employed from the commencement, no change has been made in the manuring up to the present time.

As in the case of plot 5, the following table (Table LXVI., pp.1312–13) gives for plot 15 the particulars of the per cent., and of the actual amount yielded, of each species among the grasses and the Miscellaneæ, which contributed in any one year more than 1 per cent. to the produce, the results for those species yielding less than this being given collectively; whilst those occurring on the unmanured plot, but not on the manured one at all, are again enumerated and bracketed together. As before, for the few species of Leguminosæ, the full details are given. But, as there was a fundamental change of manure between the third and fourth separation-years, the mean for the first three separation-years is given, and the results for the fourth (1877) separately, instead of the mean for the four years.

It should be observed that much more increase of produce was obtained on plot 15 by nitrate of soda than on plot 5 by ammonia-salts containing the same amount of nitrogen. The reduction in produce was much less in the later years by the nitrate alone than by the ammonia-salts alone; much more nitrogen was yielded in the produce by the nitrate, and the decline in the yield of it was much less; one and a-half time as much mineral matter was taken up by the herbage on the nitrate plot, including, besides soda which was supplied in the manure, more lime, more magnesia, and much more potass, phosphoric acid, and silica; all of which must have been derived from the stores of the soil itself. Lastly, the decline in the amount of mineral matter taken up in the later years was less than with the ammonia-salts.

For an explanation of the much greater result in almost every particular of production with the nitrate of soda than with ammonia-salts containing the same quantity of nitrogen, we must look to the difference in the condition and distribution of the nitrogen within the soil, and to the coincident great difference in the flora in the two cases. The nitrogen of the nitrate distributes much more rapidly than does that of the ammonia-salts; much of the ammonia being probably in the first instance retained as such in the upper layers of the soil, and only gradually oxidating and distributing as nitrites or nitrates. The result is that many more species are favoured by the nitrate; a greater variety of grasses contribute to the bulk of the produce; and leguminous, and especially miscellaneous species, are more favoured. Accordingly, there is a much greater variety of "habit" developed under the influence of the nitrate, and a much more extended range of soil is commanded by the roots of the more varied herbage. Hence much more mineral matter is derived from the stores of the soil, and the different plants, especially the grasses, yield much more stem and mature much better. Indeed, as will be seen, some of the most deeply-penetrating grasses flourish under these conditions.

TABLE LXVI.—Number of Species, Percentage, Quantity per Acre, &c.,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	Mean.	1877.	1862.	1867.	1872.	Mean.	1877.
NUMBER OF SPECIES.										
Gramineæ	17	16	17	17	15	...	...	...	...	...
Leguminosæ	4	4	3	4	4	...	...	...	...	...
Other Orders	18	19	19	18	24	...	...	...	...	...
Total	39	39	39	39	43	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	1·62	1·83	4·49	2·71	4·16	74·4	96·7	164·8	111·9	157·4
Alopecurus pratensis	6·30	5·26	7·48	6·10	7·17	281·9	314·8	460·6	298·8	371·3
Agrostis vulgaris	7·65	6·96	7·06	7·39	12·90	312·6	362·6	289·3	319·5	489·1
Holcus lanatus	7·61	11·41	5·32	8·23	14·95	311·0	624·3	194·6	376·6	560·7
Avena pubescens	2·53	0·70	1·56	1·93	0·13	144·2	37·0	87·1	79·4	119·4
Avena flavescens	3·96	4·20	3·83	3·99	2·98	157·7	225·2	140·1	174·3	112·8
Poa trivialis	0·53	23·67	7·95	12·72	0·05	260·8	1261·2	280·9	600·9	229·9
Dactylis glomerata	2·39	0·21	0·11	0·90	0·36	83·4	11·1	4·0	32·8	13·6
Festuca ovina	12·69	12·09	34·71	20·16	20·77	559·3	638·5	1270·0	822·6	780·0
Festuca pratensis	0·03	0·27	0·03	0·31	1·47	1·2	14·3	23·1	12·9	55·6
Bromus mollis	2·12	6·27	4·00	4·13	1·65	98·6	331·4	146·4	192·2	62·4
Lolium perenne	7·49	3·24	4·42	5·05	7·32	306·1	171·3	161·7	213·1	277·0
None yielding 1 per cent. { Phleum pratense, Aira caspitosa, Poa pratensis, Briza media, Cynosurus cristatus, Avena elatior, Festuca pratensis	0·37	0·36	0·06	0·47	0·54	15·1	19·1	2·2	19·4	20·5
Absent—Festuca bollacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	14·87	2·51	0·96	6·01	...	606·4	132·7	35·1	254·4	...
Total	78·26	80·02	79·76	79·01	83·45	3197·7	4229·9	2931·8	3436·5	3157·7
LEGUMINOSÆ.										
Trifolium repens	0·04	0·03	0·06	0·06	0·01	1·6	4·2	2·2	2·7	0·4
Trifolium pratense	0·20	0·04	0·03	0·09	0·31	8·2	2·1	1·1	3·8	11·7
Trifolium procumbens	0·01	...	...	0·01	...	0·4	...	...	0·1	...
Lotus corniculatus	0·02	0·35	0·03	0·13	0·01	0·8	18·6	1·1	6·8	0·4
Lathyrus pratensis	...	0·04	...	0·01	1·47	...	2·1	...	0·7	55·6
Total	0·27	0·51	0·12	0·30	1·80	11·0	26·9	4·4	14·1	68·1
OTHER ORDERS.										
Ranunculus acris	0·46	0·25	1·24	0·85	2·74	18·8	13·2	45·4	25·8	141·3
Ranunculus repens et bulbosus	1·80	0·39	0·39	0·86	0·49	73·6	20·6	14·3	36·2	18·5
Cerastium triviale	1·07	3·62	9·26	4·67	0·59	43·7	194·5	338·9	192·4	22·3
Galium verum	...	1·06	1·21	0·76	0·23	...	56·1	44·3	33·5	8·7
Centaurea nigra	...	0·17	2·58	0·92	0·90	...	9·0	94·4	34·5	34·0
Achillea Millefolium	2·53	1·13	2·60	2·08	0·56	103·4	59·7	95·1	86·1	22·0
Taraxacum officinale	1·20	0·11	0·10	0·47	0·08	49·0	5·8	3·7	19·5	3·0
Plantago lanceolata	6·92	4·67	0·28	3·95	0·56	282·8	246·9	10·3	180·0	21·2
Rumex Acetosa	6·64	7·34	2·06	5·34	5·79	271·3	388·0	75·4	244·9	219·1
None yielding 1 per cent. { Stellaria graminea, Potentilla reptans, Conopodium denudatum, Pimpinella Saxifraga, Heracleum Sphondylium, Galium Aparine, Sedum arvense, Leontodon hispidus, L. autumnalis, Veronica Chamædrys, V. serpyllifolia, Ajuga reptans, Scilla nutans, Luzula campestris, Carex præcox, Hypnum squarrosum, H. rusciforme, H. triquetrum, H. loreum	0·85	0·67	1·40	0·99	1·79	34·7	35·4	51·1	40·2	67·9
Absent { Agrimonia Eupatoria, Potentilla fragariastrum, Spiræa Ulmaria, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Primula veris, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	21·47	19·47	21·12	20·69	14·75	877·3	1029·2	772·9	893·1	558·2
SUMMARY.										
Gramineæ	78·26	80·02	79·76	79·01	83·45	3197·7	4229·7	2931·8	3436·5	3157·7
Leguminosæ	0·27	0·51	0·12	0·30	1·80	11·0	26·9	4·4	14·1	68·1
Other Orders	21·47	19·47	21·12	20·69	14·75	877·3	1029·2	772·9	893·1	558·2
Total	100·00	100·00	100·00	100·00	100·00	4086	5286	3659	4344	3784

of each Species, by 550 lbs., Nitrate of Soda alone; Plot 15.

Increase + or decrease − compared with:—									
Plot 3, without manure.					Plot 5, ammonia-salts alone.				
1862.	1867.	1872.	Mean.	1877.	1862.	1867.	1872.	Mean.	1877.
Number of Species (continued).									
− 1	+1	0	0	−2	0	+1	+2	+1	+ 2
0	0	− 1	0	0	0	0	0	0	+ 2
−10	−5	− 9	−9	−7	+1	+2	+6	+3	+10
−11	−4	−10	−9	−9	+1	+3	+8	+4	+14
Graminеæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 56·2	− 191·8	+ 78·8	− 56·4	+ 36·4	−140·0	− 85·5	+ 97·9	− 49·5	+ 30·7
+ 144·9	+ 130·8	+ 61·5	+ 115·7	+ 264·2	+250·9	+ 299·0	+ 69·2	+ 206·4	+264·5
− 34·1	+ 76·1	+ 15·0	+ 19·7	+ 174·2	−233·9	− 230·7	− 268·9	− 447·9	−851·6
+ 187·2	+ 350·6	+ 135·4	+ 217·1	+ 269·0	− 77·5	+ 454·0	+ 146·9	+ 174·4	+474·8
− 150·3	− 63·3	− 1·9	− 72·5	+ 54·8	−137·5	+ 10·2	+ 51·1	− 23·5	+114·9
+ 85·3	+ 163·2	+ 82·7	+ 110·4	+ 87·3	+132·7	+ 210·0	+ 133·5	+ 159·4	+112·5
+ 219·8	+1312·5	+ 292·7	+ 871·6	+ 215·7	+232·8	+1941·3	+ 276·1	+ 883·3	+229·2
+ 31·7	− 46·9	− 10·8	− 8·7	− 2·0	− 6·7	− 54·9	− 13·6	− 18·4	− 82·8
+ 158·4	+ 132·0	+ 913·8	+ 399·3	+ 268·5	−288·2	− 372·1	+ 99·5	− 187·0	−787·7
...	+ 14·3	+ 22·9	+ 12·4	+ 58·4	− 12·3	+ 10·0	+ 22·6	+ 6·8	+ 58·8
+ 82·8	+ 329·7	+ 146·2	+ 186·2	+ 62·4	+ 83·5	+ 331·4	+ 146·4	+ 187·2	+ 62·4
+ 111·7	+ 87·0	+ 122·7	+ 90·5	+ 169·4	+177·9	+ 131·3	+ 197·4	+ 148·9	+274·3
− 59·4	− 20·6	− 103·0	− 61·1	− 177·9	−180·6	− 94·9	− 28·9	− 101·5	+ 6·9
...	...	...	...	− 0·7	...	...	...	...	...
+ 356·1	− 71·8	− 13·8	+ 90·2	...	+462·4	+ 79·4	+ 11·3	+ 184·3	...
+1042·7	+2046·5	+1753·0	+1614·1	+1473·7	−129·1	+1854·5	+ 752·5	+ 826·0	+351·0
Leguminosæ (continued).									
− 14·9	− 2·8	− 4·0	− 7·1	− 2·7	+ 1·2	+ 2·9	+ 1·9	+ 2·4	+ 0·4
− 129·5	− 68·2	− 36·5	+ 7·4	− 37·7	+ 6·7	+ 1·8	+ 1·1	+ 2·3	+ 11·7
+ 0·4	...	...	+ 0·1	...	+ 0·4	...	...	+ 0·1	...
− 55·1	− 39·8	− 26·6	− 70·5	− 93·0	− 1·1	+ 8·2	− 9·2	− 0·7	− 3·7
− 38·4	− 30·6	− 18·1	− 25·0	− 0·4	− 0·8	+ 1·8	− 1·0	...	+ 54·1
− 236·2	− 151·4	− 143·2	− 176·9	− 133·8	+ 6·4	+ 15·7	− 7·2	+ 5·0	+ 62·5
Other Orders (continued).									
+ 18·5	+ 12·9	+ 44·2	+ 25·2	+ 141·5	+ 18·4	+ 12·5	+ 44·6	+ 25·2	+139·4
− 75·3	− 46·4	− 34·0	− 51·9	− 63·1	+ 61·3	+ 18·0	+ 12·3	+ 30·6	+ 15·9
+ 29·8	+ 136·3	+ 324·8	+ 179·0	+ 2·9	+ 42·2	+ 191·5	+ 339·8	+ 191·3	+ 22·7
...	+ 56·1	+ 44·3	+ 33·5	+ 9·7	...	+ 35·9	− 16·0	+ 6·7	+ 2·2
− 9·5	− 10·7	+ 89·8	+ 13·2	+ 8·9	− 0·4	− 71·3	+ 30·8	− 10·7	+ 18·4
+ 56·7	+ 21·0	+ 62·9	+ 47·9	− 22·0	+ 82·2	+ 22·7	+ 69·7	+ 49·2	+ 17·9
+ 47·5	+ 0·4	+ 1·2	+ 16·4	+ 1·6	+ 48·6	+ 5·3	+ 3·2	+ 19·1	+ 3·0
+ 59·9	− 110·6	− 33·4	− 28·4	− 53·5	+278·0	+ 240·2	+ 10·3	+ 176·5	+ 21·2
+ 228·8	+ 329·3	+ 46·3	+ 201·4	+ 174·9	− 61·3	− 159·0	− 103·8	− 108·1	+150·2
− 123·3	− 363·8	− 104·7	− 198·7	− 88·9	− 66·4	− 213·2	+ 2·0	− 92·7	− 4·8
− 2·1	− 9·6	− 9·1	− 7·1	− 29·9	...	...	...	...	− 2·6
+ 227·5	+ 58·9	+ 405·2	+ 230·5	+ 79·1	+354·7	+ 109·8	+ 339·7	+ 288·1	+388·5
Summary (continued).									
+1042·7	+2046·5	+1753·0	+1614·1	+1473·7	−129·1	+1854·5	+ 752·5	+ 826·0	+351·0
− 236·2	− 151·4	− 143·2	− 176·9	− 133·8	+ 6·4	+ 15·7	− 7·2	+ 5·0	+ 62·5
+ 227·5	+ 58·9	+ 405·2	+ 230·5	+ 79·1	+354·7	+ 109·8	+ 339·7	+ 288·1	+388·5
+1034	+1954	+2015	+1668	+1420	+232	+1990	+1145	+1119	+832

Whilst on plot 5, with ammonia-salts, the number of species found in the samples declined in the first three separation-years from 38 to 36 and 31, on plot 15, with the nitrate of soda, it was 39 in each of the three years; and whilst it declined to 29 in the fourth separation-year with ammonia-salts, it rose to 43 on plot 15 after the mixed mineral manure had been substituted for the nitrate.

The table shows that there was much less fluctuation, and a lower mean percentage of gramineous herbage, on plot 15 than on plot 5; the highest amount was little over 80 per cent., the fact being that a much larger number of miscellaneous species contributed their share to the yield.

A glance at the figures more in detail brings to view the fact that no one grass contributed such an overwhelming percentage as on plot 5, and that a much larger number yielded a fair proportion. Here again, however, *Festuca ovina* furnished in the third separation-year rather more than one-third of the whole; but in neither year did *Agrostis vulgaris* contribute an excessive proportion as it did on plot 5. The most prominent among the other grasses were—*Poa trivialis* and *Holcus lanatus*, both of which increased in the second year (1867), *Poa trivialis* very considerably, although it diminished in the third year (1872); *Alopecurus pratensis* and *Lolium perenne*, both of which however declined; *Avena flavescens* in smaller but comparatively uniform percentage; and *Anthoxanthum* and *Bromus mollis* which increased. Lastly, those which were in fair proportion in the first year, but which were reduced very considerably subsequently, were *Avena pubescens* and *Dactylis glomerata*. The mere length of this enumeration is sufficient to show how many more grasses were enabled to maintain or improve their position in the struggle under the difference of condition, and more extended distribution, of the manurial agent within the soil, the correspondingly increased root-range, and the greater command of the mineral food of the soil and subsoil. It is due to the same causes that the grasses showed a much greater tendency to the formation of stem; and an examination of the right hand columns of the table, in which the results are compared with those relating to plot 5 with the ammonia-salts, will show that several species of freer growth, and higher agricultural repute, were brought into greater prominence.

As with the ammonia-salts so with the nitrate of soda, the highly nitrogenous Leguminosæ were much discouraged, but in a somewhat less degree.

Of miscellaneous plants one only, *Rumex Acetosa*, was really prominent on plot 5 with the ammonia-salts, *Conopodium denudatum* coming second, and *Centaurea nigra* developed more occasionally. On plot 15, with the nitrate of soda, both *Rumex Acetosa* and *Plantago lanceolata* were prominent in the first and second separation-years; but each went down considerably in the third; *Conopodium denudatum*, which, as already said, was the second in prominence with the ammonia-salts, is in quite insignificant amount with the nitrate of soda; *Centaurea nigra* is also less prominent with the nitrate. The plant which has developed in the most striking degree under the influence of the nitrate is *Cerastium triviale*, which increased from little over

1 per cent. in the first, to nearly 4 in the second, and to more than 9 in the third separation-year; contributing in that season not far from half of the total miscellaneous herbage. Lastly, whilst *Ranunculus repens* and *R. bulbosus* have diminished, the more deeply-rooting *Ranunculus acris* has increased.

Thus, as is the case with the gramineous herbage so with the miscellaneous, it is very much more mixed under the influence of the nitrate than under that of the ammonia-salts.

Looking to the columns of produce, and of increase, per acre over the unmanured of each group, or of each species of plants, it is observed that there was a very great increase in the total gramineous herbage—nearly twice as great in the second year as in the first, but somewhat less in the third than in the second. In the first year there was even less of such increase than with the ammonia-salts (plot 5), but in the second year there was very much more, and in the third considerably more by the nitrate than by the ammonia.

Of leguminous herbage there was actually much less each year with the nitrate alone than in the same years without manure, and on the average there was scarcely more of such produce than with the ammonia-salts.

Of total miscellaneous herbage there was actually more in the second than in the first or third year, but owing to the very large amount without manure also, in the second year, there was much less increase by the nitrate in that year than in either the first or the third; indeed, very little. There was also a larger actual quantity of total miscellaneous herbage with the nitrate than with the ammonia-salts, the excess being, however (notwithstanding the large actual quantity), considerably less in the second year (1867).

Referring to the actual yield, that is to the quantity per acre, of the individual species among the grasses, *Festuca ovina* contributes by far the largest amount—more than without manure, and in the third year very much more; less, however, in the first and second years than by ammonia-salts. *Agrostis vulgaris*, which contributed so much on the ammonia plot, yielded very much less with the nitrate. Next in order of actual amount to *Festuca ovina* comes *Poa trivialis*, nearly the whole of the produce of which was, each year, in excess of the amounts of it on either the unmanured plot 3, or the ammonia plot 5, on both of which it occurred in very insignificant quantity; whilst it is to be observed that the nearly allied *Poa pratensis* was scarcely represented on the nitrate plot at all. *Holcus lanatus* gave on the average a fair yield, but much more in the second than in the first or third year; considerably more in each year than on the unmanured plot, and in the second year much more, and in the third more, than on the ammonia plot 5. *Alopecurus pratensis*, *Avena flavescens*, and *Lolium perenne* also contributed notably to the produce, and each of them materially more than either without manure or with ammonia-salts. In a word, the gramineous herbage was considerably more in actual amount, and very much more mixed than under the influence of the ammonia-salts. It may, however, be noted that

Phleum pratense, *Avena elatior*, *Cynosurus cristatus*, *Briza media*, and also *Poa pratensis*, were in very insignificant quantities.

The yield per acre of leguminous herbage was in every case insignificant, but it was greater in the second than in either the first or the third year, and the diminution in the total yield of such herbage compared with that of the unmanured plot was due to a decrease in each of the four species—*Trifolium repens*, *T. pratense*, *Lotus corniculatus*, and *Lathyrus pratensis*. On the nitrate plot, however, *Trifolium procumbens* occurred, but in very small amount, and it was not observed on either the unmanured or the ammonia plot, although the plant is not uncommon in the neighbourhood.

Of miscellaneous herbage *Rumex Acetosa* contributed the largest actual amount, much more than without manure, but in each year considerably less than with ammonia-salts. *Plantago lanceolata* also contributed largely in the first and second separation-years, but very little in the third; indeed, less in both the second and third years than without manure, but in the first and second years considerably more, and in the third somewhat more than with ammonia-salts. As already observed, the only miscellaneous plant which increased in a marked manner on this nitrate plot was *Cerastium triviale*, which contributed in the third year nearly half the total miscellaneous herbage, and in each year almost the whole was in excess of that yielded either without manure or with ammonia-salts. The great abundance of *Cerastium* may perhaps be partially accounted for, amongst other characteristics, by its early and free seeding, as already referred to. *Centaurea nigra* yielded practically nothing in the first and second separation-years, and less in those years on this plot than either without manure or with ammonia-salts, but it gave a fair amount in the third year, and then more than either without manure or with ammonia-salts. It should be borne in mind, however, that from the size and character of the plant there is some difficulty in securing a fair proportion of it in the samples. *Achillea Millefolium* perhaps came next in order of yield to *Cerastium*, not indeed contributing much, but still considerably more than without manure or with ammonia-salts. Then come the various species of *Ranunculus* collectively, only the more deeply-rooting *R. acris* increasing, and giving more each year than either without manure or with ammonia-salts, while the generally shallower rooting *R. repens* and *R. bulbosus* decline in yield, and give much less than without manure, though still more than with ammonia-salts. The only other plant in any noticeable quantity was *Galium verum*, which was practically unrepresented on the unmanured plot, but which in the third separation-year was even in larger amount on the ammonia than on the nitrate plot. Like *Cerastium triviale*, *Galium* is a plant of relatively meagre development, rooting chiefly at, or at a short distance beneath, the surface.

We have then, under the influence of excessive application of nitrate of soda alone, a very much more uniformly mixed herbage than with an amount of ammonia-salts containing the same quantity of nitrogen. There is not only much more produce, both of Graminæ and of Miscellaneæ, but there is a less excessive proportion of the grasses,

and a greater number, both of them and of the miscellaneous species, contribute a fair proportion to the mixed herbage. Of the grasses, several of freer habit of growth, and of better character, are fairly represented, whilst among the Miscellaneæ there is not the almost exclusive predominance of *Rumex Acetosa* as was the case with the ammonia-salts, other plants, both of superficial and deeper foraging tendencies, finding a due place.

During the 18 years' application of the nitrate of soda the plot exhibited a very different general aspect from that of the ammonia plot. The herbage of the ammonia plot was almost exclusively leafy, and extremely dark green, indicating, as is known, a very high percentage of nitrogen in the dry substance, and, it is to be supposed, a liberal formation of chlorophyll; yet, as has been seen, there was extremely restricted vegetation (carbon assimilation), and scarcely any tendency to maturation. The nitrate plot (15) showed somewhat similar characters, but in a very much less degree; the herbage was much more characteristically leafy than where mineral manures are employed in conjunction with the nitrate, but there was much more luxuriance, much more tendency to form stem, and a much lighter and healthier colour than with the ammonia. Though more nitrogen was taken up, there was a less percentage of it in the dry substance of the produce. In other words, for a given amount of nitrogen taken up there had been much more carbon assimilation, that is to say, much more growth, due doubtless in great part to the greater supply of mineral constituents derived from the soil by the more varied and more deeply-rooting herbage.

We have now to call attention to the changes induced in the botanical composition of plot 15 by the cessation of the application of the nitrate, and the substitution of a mixed mineral manure, including potass. Although 1877, the fourth year of separation, was only the second after the change of manuring, the table shows that a considerable change in the flora was then already indicated, and it has been much more marked in subsequent years, as has been shown by the partial separations which have since been undertaken.

Referring first to the results for 1877, as given in the table, perhaps the most marked feature is the tendency already developed to increase in the Leguminosæ, and especially in *Lathyrus pratensis*, which in subsequent years continued to increase in a rapid ratio.

There was, after the change, so much fluctuation in the proportion to one another of the grasses and the Miscellaneæ, according to season, that it is difficult to say with regard to either group as a whole, whether the tendency was to increase or decrease as the direct effect of the altered condition of manuring.

It will be remembered that, with the ammonia-salts alone, *Festuca ovina* and *Agrostis vulgaris* almost entirely displaced the other grasses; and that, with the nitrate of soda alone, *Festuca ovina* also gained ground, and was by far the most prominent of the gramineous species, whilst *Agrostis vulgaris* was in very much less amount, a number

of other species contributing a due proportion. The table shows that in the second year only (1877) of the substitution of the mixed mineral manure (including potass) for the nitrate, *Festuca ovina* had already considerably declined, though still remaining the most prominent species; *Agrostis vulgaris*, on the other hand, had considerably gained ground, both in percentage and in actual yield per acre. Of other grasses, *Holcus lanatus* increased very much, both in percentage and in actual quantity, under the influence of the change to mineral manure, and *Alopecurus pratensis*, *Avena pubescens*, and *Lolium perenne* did so in a less degree; *Poa trivialis*, *Avena flavescens*, and *Bromus mollis*, however, declined.

It should be observed that the difference in proportion and amount of the different grasses indicated by the figures by no means represents the whole of the change in the herbage, resulting from the change of manure; for, under the influence of the mineral manure, there was a much lighter colour, and a much greater tendency to form stem and to mature, than under the influence of the nitrate, and the question arises whether it may not be owing to this different tendency of growth induced by the manure that certain species have yielded a larger proportion and amount.

Referring to the Leguminosæ, *Lathyrus pratensis*, as already intimated, showed a tendency to considerable increase, and it has done so in a very marked degree since. It will be seen further on, that this result is quite consistent with that obtained where mixed mineral manure, including potass, has been applied every year from the commencement.

Among the Miscellaneous species, perhaps the most marked change resulting from the application of the mineral manure instead of the nitrate is the great increase in *Ranunculus acris*, a recurrence of a large proportion and amount of *Rumex Acetosa*, and a very great diminution in *Cerastium triviale*, which had, it will be remembered, become so remarkably prominent under the influence of the nitrate. Of other species, all were more or less discouraged, *Achillea Millefolium* perhaps the most conspicuously so.

We now turn to the results obtained on plot 17, receiving only half as much nitrate of soda as plot 15; and, therefore, only half as much nitrogen, and only half as much as in the ammonia-salts supplied to plot 5.

Before going into the detail of the botany of the plot, it is necessary to call to mind some of the particulars of production compared with those on plots 5 and 15 respectively. There was, with the smaller quantity of nitrogen as nitrate, much more produce than with double the quantity as ammonia-salts, and very little less than with double the quantity as nitrate of soda. There was much more nitrogen taken up in the produce than with the double quantity as ammonia, and though a less actual amount than with the double quantity as nitrate, a larger proportion of that supplied was recovered in the increase. Much more mineral matter was taken up than with the

ammonia, nearly as much as with the double nitrate, and even more of lime, potass, and silica, which were, of course, derived from the soil itself.

This brief enumeration of general characters of produce is sufficient to indicate that there was a difference in the flora also, as Table LXVII., pp. 1320–21, clearly illustrates.

An examination of the figures in the table shows that, as compared with double the quantity of nitrogen as ammonia-salts, the increase obtained by the smaller quantity of nitrate of soda was chiefly in the Graminæ, but considerable also in the Leguminosæ and in the miscellaneous herbage. As compared with the results obtained with the double quantity of nitrate, the small total deficiency was chiefly in the grasses, whilst there was, on the average, an increase in the amount of both the leguminous and the miscellaneous species.

The columns of percentage of the individual species show at a glance much less excess of any single plant—in fact, a much more generally mixed herbage than with the double amount of nitrogen, whether as ammonia-salts or as nitrate of soda. Now, neither *Festuca ovina* nor *Agrostis vulgaris* takes the first place over the average of the four separation-years; *Alopecurus pratensis* is here, on the average, the most prominent plant, though, it is true, declining from the first to the fourth separation-year. *Agrostis vulgaris* and *Festuca ovina* come next in average proportion, each varying considerably in prominence, but the two somewhat in opposite directions, from year to year. An examination of the climatal characters of the seasons of separation, and of the intervening ones, will show that the fluctuations in the relative prevalence of these two plants were such as might be expected, the freer-growing, creeping, and moisture-loving *Agrostis* being the more prominent in the years of comparatively luxuriant growth, and *Festuca ovina* in those of generally more restricted gramineous luxuriance. Next in order to these, the three most prominent of the grasses on plot 17, come *Holcus lanatus*, *Lolium perenne*, *Anthoxanthum odoratum*, and *Avena pubescens*, each of which contributed a fair proportion. *Avena flavescens* was, upon the whole, less prominent than *A. pubescens;* and *Poa trivialis*, which was prominent in the earlier, greatly declined in the later years. Upon the whole, however, the gramineous herbage was, as has been said, of a mixed character.

Although Leguminosæ were much less discouraged with the smaller than with the larger quantity of nitrate, and especially less than with the ammonia-salts, no species of this Order gained any degree of prominence, all being in considerably less proportion, and amount, than even without manure. But the leguminous plant which best maintained its position was the deeply-rooting *Lotus corniculatus*, which is also the most prominent of the Leguminosæ on the unmanured plots.

The miscellaneous herbage was not only more in quantity than either without manure, with the ammonia-salts, or even than with the double quantity of nitrate, but different plants became prominent. For example, as will be remembered, with the double nitrate *Cerastium triviale* increased in an extraordinary degree, whereas, with the smaller quantity, in neither corresponding year did it yield one-third as much. With

Table LXVII.—Number of Species, Percentage, Quantity per Acre,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species.										
Gramineæ	16	16	17	16	16	...	...	...	...	...
Leguminosæ	4	3	4	4	4	...	...	...	...	...
Other Orders	13	23	22	29	22	...	...	...	...	...
Total	33	42	43	49	42	...	...	...	...	...
Gramineæ.										
Anthoxanthum odoratum	p. c. 2·06	p. c. 2·31	p. c. 4·50	p. c. 5·82	p. c. 3·55	lbs. 91·6	lbs. 117·4	lbs. 149·5	lbs. 196·9	lbs. 139·4
Alopecurus pratensis	23·94	21·71	16·25	12·72	18·66	1064·4	1102·4	540·0	475·5	795·8
Agrostis vulgaris	11·01	7·05	10·60	17·92	11·64	489·5	358·3	352·2	669·3	467·4
Holcus lanatus	9·23	9·13	5·97	10·91	8·28	365·9	413·2	199·1	407·8	345·5
Avena pubescens	4·24	1·15	4·09	4·27	3·44	188·5	58·5	135·9	159·6	135·6
Avena flavescens	1·43	2·16	4·99	1·96	2·89	64·5	161·6	164·9	74·0	116·2
Poa trivialis	5·21	12·08	2·74	1·59	5·40	231·6	613·4	91·1	59·4	248·9
Dactylis glomerata	1·80	0·57	0·64	0·56	0·90	80·0	29·0	21·3	21·7	38·0
Festuca ovina	9·43	11·18	19·05	12·04	12·67	419·3	568·2	630·8	450·0	509·3
Bromus mollis	0·18	2·28	0·81	0·15	0·85	8·0	114·9	26·9	5·6	38·9
Lolium perenne	5·09	3·23	2·94	6·68	4·49	226·3	164·2	97·7	249·7	184·5
None yielding 1 per cent. (Aira cæspitosa, Avena elatior, Poa pratensis, Briza media, Cynosurus cristatus, Festuca pratensis)	1·32	1·01	1·24	1·71	1·32	58·7	51·5	41·3	64·0	53·9
Absent—Phleum pratense, Festuca hollacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	7·40	1·86	0·58	...	2·47	329·9	94·5	19·3	...	110·6
Total	81·36	75·72	73·27	75·87	76·56	3617·2	3848·1	2434·7	2836·0	3184·0
Leguminosæ.										
Trifolium repens	0·05	0·32	0·09	0·01	0·11	2·2	16·3	3·0	0·4	5·5
Trifolium pratense	0·31	0·26	0·12	0·11	0·17	13·6	13·2	4·0	4·1	8·9
Lotus corniculatus	0·05	0·12	1·16	0·78	0·34	2·2	6·1	38·6	29·1	19·0
Lathyrus pratensis	0·01	...	0·01	0·01	0·23	0·5	...	0·3	0·4	0·3
Trifolium procumbens	...	...	...	...	...	...	...	...	...	...
Total	0·42	0·70	1·38	0·91	0·85	18·7	35·6	45·9	34·0	33·6
Other Orders.										
Ranunculus acris	0·14	0·29	1·15	2·95	1·13	6·2	14·7	38·2	110·3	42·4
Ranunculus repens et bulbosus	1·95	1·04	1·33	1·96	1·57	86·7	52·8	44·2	73·3	64·2
Cerastium triviale	0·29	1·00	2·05	0·39	1·18	12·9	50·8	101·4	14·6	44·9
Conopodium denudatum	1·48	2·44	1·81	0·72	1·53	65·8	124·4	60·2	26·9	68·8
Centaurea nigra	4·41	4·10	10·28	2·82	5·40	196·1	208·3	341·6	105·4	212·3
Achillea Millefolium	2·14	1·39	2·91	1·39	1·95	95·1	70·6	96·7	51·9	76·6
Plantago lanceolata	3·85	4·83	7·41	7·99	4·77	171·2	245·4	80·1	298·7	198·8
Rumex Acetosa	3·57	7·53	1·58	2·36	3·81	158·7	382·7	52·5	88·7	172·4
None yielding 1 per cent. (Stellaria graminea, Hypericum perforatum, Potentilla reptans, Pimpinella Saxifraga, Heracleum Sphondylium, Scabiosa arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, L. autumnalis, Taraxacum officinale, Hieracium Pilosella, Veronica Chamædrys, V. serpyllifolia, Prunella vulgaris, Ajuga reptans, Primula veris, Luzula campestris, Carex præcox, Hypnum squarrosum, H. triste, H. rusbeckium)	0·39	0·96	1·13	2·44	1·23	17·4	42·6	37·5	91·2	42·8
Absent (Agrimonia Eupatoria, Poterium Sanguisorba, Galium Aparine, Thymus Serpyllum, Scilla nutans, Ophioglossum vulgatum)	...	...	...	...	...	...	...	...	...	...
Total	19·22	23·38	29·35	23·22	22·59	810·1	1199·3	842·4	868·0	929·7
Summary.										
Gramineæ	81·36	75·72	73·27	75·87	76·56	3617·2	3848·1	2434·7	2836·0	3184·0
Leguminosæ	0·42	0·70	1·38	0·91	0·85	18·7	35·6	45·9	34·0	33·6
Other Orders	18·22	23·58	25·35	23·22	22·59	810·1	1199·3	842·4	868·0	929·7
Total	100·00	100·00	100·00	100·00	100·00	4446	5082	3323	3738	4147

&c., of each Species, by 275 lbs. Nitrate of Soda alone; Plot 17.

Increase + or decrease − compared with:—

Plot 3, without manure.					Plot 15, 550 lbs. nitrate, to 1875.					Plot 5, ammonia-salts alone.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	Mean.*	1877.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).														
− 2	+1	0	−1	−1	−1	0	0	0	+1	−1	+1	+ 2	+ 3	+1
0	−1	0	0	0	0	−1	+1	0	0	0	+1	+ 1	+ 2	+1
−15	−1	−6	−2	−6	−5	+4	+3	+1	−2	−4	+6	+ 9	+15	+7
−17	−1	−6	−3	−7	−6	+3	+4	+1	−1	−5	+6	+12	+20	+9
Gramineæ (continued).														
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 30·0	− 171·1	+ 64·0	+ 17·9	− 17·0	+ 17·2	+ 29·7	− 14·8	+ 7·7	+ 41·9	− 126·8	− 64·8	+ 79·1	+ 78·2	− 11·0
+ 927·4	+ 909·5	+ 531·5	+ 469·4	+ 709·2	+782·5	+788·9	+450·0	+673·8	+204·2	+1039·4	+1067·9	+819·2	+ 468·7	+778·6
+ 142·8	+ 70·8	+ 86·9	+ 335·9	+ 164·0	+176·9	− 4·3	+ 71·9	+ 81·5	+181·7	− 447·0	− 335·0	−317·0	− 199·9	−324·8
+ 217·1	+ 147·7	+ 130·9	+ 111·1	+ 151·7	+ 54·9	−211·1	+ 0·5	− 51·9	−187·8	− 22·6	+ 242·9	+147·4	+ 316·9	+171·7
− 100·0	− 43·8	+ 77·4	+ 86·0	+ 5·9	+ 44·3	+ 21·5	+ 79·7	+ 48·2	+ 41·2	− 33·2	+ 37·7	+129·8	+ 156·1	+ 57·6
− 7·9	+ 99·6	+ 107·4	+ 48·5	+ 61·9	− 32·2	− 63·6	+ 24·7	− 44·0	− 30·8	+ 39·5	+ 186·4	+160·2	+ 73·7	+104·9
+ 134·9	+ 674·4	+ 97·9	+ 46·2	+ 222·0	− 35·2	−637·9	−199·8	−291·0	−109·5	+ 197·1	+ 663·5	+ 76·3	+ 19·1	+234·0
+ 32·3	− 29·0	+ 0·5	+ 5·1	+ 2·2	− 5·4	+ 17·9	+ 17·3	+ 9·9	+ 8·1	− 12·1	− 17·0	+ 3·7	− 74·2	− 24·9
+ 19·4	+ 61·7	+ 243·6	− 67·5	+ 62·9	−140·0	− 70·3	−470·2	−293·5	−336·0	+ 429·2	+ 442·4	−570·7	−1122·7	−641·2
+ 4·0	+ 113·2	+ 20·7	+ 5·6	+ 37·4	− 78·6	−216·5	−119·5	−138·2	− 56·9	+ 114·9	+ 287·9	+ 0·4	+ 6·6	+ 52·1
+ 31·9	+ 29·9	+ 58·7	+ 142·1	+ 65·7	− 79·9	− 7·1	− 64·0	− 50·3	− 27·3	+ 98·0	+ 134·2	+ 73·4	+ 247·0	+135·7
− 16·7	+ 11·8	− 89·1	− 134·6	− 56·3	+ 45·3	+ 27·6	− 3·4	+ 23·2	− 12·1	− 150·5	− 66·8	− 12·3	+ 49·8	− 45·0
− 0·3	...	...	− 0·7	− 0·3	− 2·9	− 9·5	− 2·6	− 5·0	...	...	...	...	...	...
+ 89·6	− 110·0	− 29·5	...	− 17·3	−206·5	− 38·2	− 15·9	−106·9	...	+ 135·9	+ 41·2	...	...	+ 59·1
+1462·2	+1664·7	+1308·9	+1154·0	+1396·4	+419·5	−361·9	−447·1	−136·5	−321·7	+ 290·4	+1472·7	+309·4	+ 59·3	+531·9
Leguminosæ (continued).														
− 14·0	+ 9·3	− 9·2	− 2·7	− 2·6	+ 0·8	+ 12·1	+ 0·9	+ 4·5	...	+ 1·9	+ 16·0	+ 2·7	+ 0·4	+ 5·2
− 122·9	− 87·1	− 23·6	− 46·3	− 62·2	+ 5·6	+ 11·1	+ 2·9	+ 6·5	− 7·6	+ 12·3	+ 12·9	+ 4·0	+ 4·1	+ 5·4
− 53·7	− 72·2	− 59·1	− 64·3	− 62·3	+ 1·4	− 12·4	+ 37·5	+ 8·8	+ 29·7	− 4·2	+ 29·3	+ 22·0	+ 2·0	+ 12·3
− 37·9	− 22·7	− 15·8	− 56·6	− 33·0	+ 0·5	− 2·1	+ 0·3	− 0·4	− 55·2	− 0·3	− 0·3	− 0·7	− 1·1	− 0·6
...	...	...	...	...	− 0·4	...	...	− 0·1	...	...	...	...	...	...
− 228·5	− 142·7	− 101·7	− 167·9	− 160·1	+ 7·7	+ 9·7	+ 41·5	+ 19·3	− 54·1	+ 14·1	+ 54·4	+ 34·3	+ 29·4	+ 25·3
Other Orders (continued).														
+ 5·9	+ 14·4	+ 37·0	+ 110·3	+ 41·9	− 12·6	+ 1·8	− 7·2	− 6·1	− 31·2	+ 5·8	+ 14·0	+ 37·4	+ 109·2	+ 41·4
− 62·2	− 14·2	− 4·1	− 8·3	− 22·2	+ 13·1	+ 32·2	+ 29·9	+ 25·1	+ 54·8	+ 74·4	+ 50·2	+ 42·2	+ 70·7	+ 59·4
− 1·2	+ 28·6	+ 87·4	− 4·8	+ 30·0	− 30·8	−143·7	−237·4	−137·3	− 7·7	+ 12·5	+ 47·8	+101·4	+ 14·6	+ 44·1
+ 30·2	+ 29·1	+ 2·4	− 18·0	+ 11·9	+ 42·1	+113·8	+ 34·5	+ 63·5	− 2·2	+ 21·5	+ 60·3	+ 24·6	+ 7·7	− 2·9
+ 186·6	+ 188·6	+ 307·0	+ 80·3	+ 190·6	+196·1	+189·3	+247·2	+214·2	+ 71·4	+ 195·7	+ 128·0	+ 286·8	+ 88·8	+175·1
+ 48·4	+ 31·9	+ 67·4	+ 4·9	+ 38·2	− 9·3	+ 10·9	+ 1·6	+ 1·4	+ 29·8	+ 43·9	+ 34·8	+ 70·3	+ 47·2	+ 49·1
− 52·9	− 112·1	+ 36·4	+ 224·0	+ 23·9	−111·6	− 1·5	+ 69·2	− 14·4	+ 27·5	+ 167·4	+ 244·7	+ 80·1	+ 226·7	+ 197·7
+ 119·0	+ 324·0	+ 23·4	+ 51·5	+ 139·7	−112·6	− 8·3	− 22·9	− 46·9	−122·4	− 193·9	− 144·3	−129·7	+ 32·8	−109·0
− 116·0	− 262·3	− 74·6	− 29·7	− 120·3	− 42·6	+ 18·0	− 1·6	− 9·7	+ 50·2	− 39·4	− 10·6	+ 13·5	+ 33·0	+ 0·1
− 0·6	− 7·0	− 8·5	− 23·3	− 9·9	...	− 56·1	− 44·3	− 33·5	− 9·5	− 0·4	− 20·2	− 60·3	− 9·4	− 22·5
+ 160·3	+ 228·0	+ 474·8	+ 387·9	+ 312·7	− 67·2	+169·1	+ 69·6	+ 57·2	+309·8	+ 287·5	+ 278·9	+469·3	+ 698·3	+433·5
Summary (continued).														
+1462·2	+1664·7	+1308·9	+1154·0	+1396·4	+419·5	−361·9	−447·1	−136·5	−321·7	+ 290·4	+1472·7	+309·4	+ 59·3	+531·9
− 228·5	− 142·7	− 101·7	− 167·9	− 160·1	+ 7·7	+ 9·7	+ 41·5	+ 19·3	− 54·1	+ 14·1	+ 54·4	+ 34·3	+ 29·4	+ 25·3
+ 160·3	+ 228·0	+ 474·8	+ 387·9	+ 312·7	− 67·2	+169·1	+ 69·6	+ 57·2	+309·8	+ 287·5	+ 278·9	+469·3	+ 698·3	+433·5
+1394	+1750	+1679	+1374	+1549	+360	−204	−336	− 60·0	− 46	+ 592	+1776	+809	+ 786	+991

* Mean of three separations only, the conditions of manuring on plot 15 having been changed after 1875.

the double nitrate *Centaurea nigra*, though it increased, occurred in only small average proportion, but with the smaller quantity it became, in the third separation-year, not only the most prominent of the miscellaneous plants, but in that year it contributed about 10 per cent. of the total produce of the plot. With the double nitrate both *Rumex Acetosa* and *Plantago lanceolata* yielded considerable average proportions, but each declined very much in the third separation-year. With the single nitrate they also declined in the third, but again rose in the fourth separation-year; the *Plantago* yielding nearly 8 per cent. of the total produce in that year. Of the species of *Ranunculus*, *R. acris* gained ground, and *R. repens* and *R. bulbosus* declined, with the double nitrate, whilst with the smaller quantity *R. repens* and *R. bulbosus* yielded fairly average amounts throughout. Of other miscellaneous species, *Achillea Millefolium* was about equally favoured on the two nitrate plots; but *Conopodium denudatum* was much less prominent with the double than with the single nitrate.

The columns showing the increase or decrease in the actual yield of each species under the influence of the smaller amount of nitrate (plot 17), as compared with the larger amount (plot 15), bring to view the difference in the herbage in the two cases still more strikingly. It is there seen how much larger an actual amount of *Alopecurus pratensis*, and how much smaller an amount, especially of *Festuca ovina*, but also of *Poa trivialis*, *Bromus mollis*, and *Lolium perenne*, was grown with the smaller than with the larger amount of nitrate. Again, among the miscellaneous plants, *Centaurea nigra* in each year contributed much more, *Conopodium denudatum*, *Ranunculus repens* and *R. bulbosus* somewhat more, but *Cerastium triviale* much less, with the smaller quantity of nitrate.

The general result is that there was a more mixed and better description of herbage with the smaller than with the larger amount of nitrate of soda, as there was a better with the larger amount than with the same amount of nitrogen applied as ammonia-salts.

From the particulars of the amounts of produce, and of their chemical and botanical characters, which have been enumerated and compared, it is to be concluded that the much more favourable conditions of growth which were induced under the influence of the larger amount of nitrogen as nitrate than with the same amount as ammonia-salts, also obtained when the smaller amount was used. Indeed, they were obviously developed in a greater degree proportionally to the amount of nitrate used with the smaller than with the larger quantity, and in some particulars, especially in so far as the botany of the plots is concerned, not only proportionally, but actually more with the smaller than with the larger amount. This result is doubtless due to a less forced luxuriance with the less excessive application of nitrate, and coincidently a more favourable balance of available mineral constituents.

4. *Mixed mineral manure, alone (including potass); Plot 7.*

Having considered the effects on the mixed herbage of applying purely nitrogenous manures, in various forms and quantities, for many years in succession, under which conditions the plants have to rely upon the soil itself for the mineral constituents required, we now come to discuss the effects of applying annually, from the commencement, a full mineral manure alone, including potass, the same as was applied to plot 15 after the application of nitrate for 18 years. Of course, now the vegetation is left to obtain its nitrogen from other sources than manure; that is, from the soil itself, or from the atmosphere, as the case may be.

Referring to Part I., p. 307, *et seq.*, for more detailed statements of the results as to the amounts of produce, of nitrogen, and of mineral matter, yielded, it may be here repeated that such a mixed mineral manure gave much more produce than ammonia-salts alone, and nearly as much as with either the smaller or the larger amount of nitrate of soda. There was also an increase in gross produce, in nitrogen, and in mineral matter, taken up over the later as compared with the earlier years. Even the gramineous herbage, so markedly influenced by nitrogenous manures, increased considerably, especially in the later years, under the influence of the purely mineral manure. Leguminous herbage, though in less actual amount than the gramineous, increased in much greater proportion, indeed, in a very striking degree. Miscellaneous plants, however, rather declined than increased.

Although no nitrogen was supplied, there was a great increase in the amount taken up as compared with the produce without manure, especially by the increased leguminous growth. Upon the whole, without nitrogenous manure, the amount of nitrogen taken up under the influence of the purely mineral manure was one and two-thirds as much as without manure, and nearly three times as much as by applying the same manure to either wheat or barley on arable land. Further, with this greatly increased yield of nitrogen in the produce, without the supply of any by manure, there was found a great reduction in the percentage of nitrogen in the upper layers of the soil, indicating the source whence the nitrogen of the vegetation had been derived.

Bearing in mind these striking facts, we now turn to the botanical characteristics of the mineral manured plot, as shown in Table LXVIII., pp. 1324–5.

As already referred to, it has been found that the number of species compared with that without manure is diminished, whatever the description of manure applied. Taking the average of the four years of complete separation, there were 49 species found in the samples from the unmanured plot, 33 only by ammonia-salts alone, 39 (over three separation-years only) with the larger quantity of nitrate, and 42 with the smaller quantity. We have now with the mixed mineral manure alone an average of 43, which is higher than on any plot with nitrogenous manure, whether used alone or in conjunction with minerals. The fact is that, with nitrogenous manure, there is more of forced luxuriance of individual species, varying, it is true,

TABLE LXVIII.—Number of Species, Percentage, Quantity per Acre, &c.,

	Number of species, and proportion per cent.				
	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.					
Gramineæ	18	18	17	17	17
Leguminosæ	4	4	4	4	4
Other Orders	22	22	20	23	22
Total	44	42	41	44	43
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.
Anthoxanthum odoratum	3·06	3·93	2·73	3·18	3·22
Alopecurus pratensis	0·34	0·86	1·17	0·46	0·72
Agrostis vulgaris	7·14	8·69	11·72	12·02	9·14
Holcus lanatus	5·06	11·81	3·16	13·16	8·29
Avena elatior	2·41	0·06	0·48	1·29	1·05
Avena pubescens	13·81	2·20	2·36	2·25	5·16
Avena flavescens	4·02	4·84	3·72	8·85	4·07
Poa pratensis	1·13	1·05	2·27	1·75	1·55
Poa trivialis	2·31	4·36	2·57	2·11	2·15
Dactylis glomerata	2·57	4·07	1·66	2·67	2·15
Festuca ovina	13·73	11·38	14·86	28·30	16·84
Bromus mollis	1·26	0·93	0·04	0·01	0·57
Lolium perenne	3·13	2·40	0·59	3·02	2·28
None yielding 1 per cent. (Phleum pratense, Alra cæspitosa, Briza media, Cynosurus cristatus, Festuca pratensis)	0·30	0·92	0·30	1·20	0·69
Absent—Festuca loliacea	...	...	...	...	...
Undetermined (chiefly Gramineæ)	2·89	2·40	1·46	...	1·68
Total	64·65	59·29	49·92	74·38	61·78
LEGUMINOSÆ.					
Trifolium repens	3·08	0·47	1·77	0·01	1·33
Trifolium pratense	0·94	4·75	1·13	1·55	2·56
Lotus corniculatus	1·27	0·69	0·19	0·04	0·55
Lathyrus pratensis	13·51	6·78	36·68	12·11	17·27
Total	24·70	12·69	39·77	13·71	22·71
OTHER ORDERS.					
Ranunculus repens et bulbosus	1·31	0·38	0·21	0·32	0·55
Cynopodium dendatum	2·03	9·22	1·31	1·56	3·53
Pimpinella Saxifraga	0·86	1·20	0·22	0·25	0·64
Achillea Millefolium	1·69	2·10	0·22	0·64	1·66
Plantago lanceolata	0·23	1·10	0·07	0·09	0·37
Rumex Acetosa	2·10	9·88	1·16	0·87	4·00
Larnia campestris	1·41	1·17	1·04	0·80	1·18
None yielding 1 per cent. (Ranunculus acris, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Sylvea Ulmaria, Heracleum Sphondylium, Galium verum, Scabiosa arvensis, Centaurea nigra, Cardus arvensis, Tragopogon pratensis, Leontodon hispidus, Taraxacum officinale, Hieracium Pilosella, Veronica Chamædrys, Prunella vulgaris, Ajuga reptans, Primula veris, Carex præcox, Ophioglossum vulgatum, Hypnum squarrosum, H. rutabulum, H. triane)	1·02	2·97	1·57	1·83	1·99
Absent (Poterium Sanguisorba, Galium Aparine, Bellis perennis, Chrysanthemum Leucanthemum, Thymus Serpyllum, Scilla nutans)	...	...	...	...	...
Total	10·65	28·02	11·41	11·91	15·51
SUMMARY.					
Gramineæ	64·65	59·29	49·92	74·38	61·78
Leguminosæ	24·70	12·69	39·77	13·71	22·71
Other Orders	10·65	28·02	11·41	11·91	15·51
Total	100·00	100·00	100·00	100·00	100·00

of each Species, by Mixed Mineral Manure alone (including Potass); Plot 7.

Quantity per acre.					Increase + or decrease − compared with plot 3, unmanured.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
...	...	...	...	...	0	+1	0	0	0
...	...	...	...	...	0	0	0	0	0
...	...	...	...	...	−6	−2	−8	−8	−6
...	...	...	...	...	−6	−1	−8	−8	−8
Graminer (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
152·4	178·2	115·2	102·2	147·0	+ 4·9	− 113·3	+ 29·7	+ 41·2	− 9·4
15·0	39·3	49·6	24·5	32·1	− 122·0	− 184·7	+ 41·1	+ 17·4	− 54·3
315·9	253·7	496·4	613·0	419·7	− 30·9	− 33·8	+ 231·1	+ 289·1	+ 116·4
223·9	208·5	132·9	671·2	309·6	+ 70·1	+ 201·0	+ 14·0	+ 874·5	+ 199·0
106·6	2·7	19·5	65·8	48·6	+ 104·5	− 4·3	+ 17·4	+ 64·6	+ 45·5
611·0	173·9	100·0	114·7	249·9	+ 316·5	+ 71·6	+ 41·6	+ 51·1	+ 120·2
177·8	216·8	157·6	366·1	184·3	+ 108·4	+ 132·8	+ 100·2	+ 189·5	+ 130·0
50·0	46·8	96·2	89·3	70·6	+ 41·1	+ 41·1	+ 94·7	+ 87·6	+ 66·2
189·6	190·2	97·4	107·6	142·2	+ 121·6	+ 150·3	+ 89·2	+ 94·4	+ 118·3
119·7	209·2	71·2	167·2	145·1	+ 62·0	+ 150·2	+ 56·4	+ 170·6	+ 109·3
807·4	807·4	629·5	1256·1	775·1	+ 201·5	+ 0·9	+ 273·3	+ 838·6	+ 328·6
55·7	43·6	1·7	0·5	25·9	+ 51·7	+ 41·8	+ 1·5	+ 0·5	+ 22·8
138·0	107·0	32·0	154·0	108·0	− 36·7	+ 27·3	− 14·0	+ 46·4	− 12·6
13·3	41·0	13·1	61·1	32·2	− 51·4	+ 14·0	− 110·7	− 134·6	− 70·6
...	...	...	...	...	...	...	...	− 0·7	− 0·7
127·9	107·0	61·8	...	74·1	− 111·4	− 97·5	+ 13·1	...	− 49·0
2860·2	2642·2	2068·0	3793·3	2841·1	+ 705·2	+ 459·8	+ 939·2	+2111·3	+1053·8
Leguminer (continued).									
136·2	21·0	75·0	0·5	58·2	+ 120·0	+ 14·0	+ 68·8	− 2·6	+ 50·1
302·9	211·9	47·9	79·1	160·4	+ 165·9	+ 141·6	+ 20·3	+ 22·7	+ 89·4
56·2	30·6	6·0	2·0	24·2	+ 0·3	− 47·5	− 89·7	− 91·4	− 57·0
597·7	302·0	1553·8	617·6	767·7	+ 550·3	+ 279·3	+1537·7	+ 561·6	+ 734·4
1092·7	565·7	1684·7	699·2	1010·6	+ 845·5	+ 387·4	+1537·1	+ 497·3	+ 816·9
Other Orders (continued).									
88·0	16·9	8·9	16·3	28·0	− 90·9	− 89·1	− 39·4	− 63·3	− 61·4
89·3	411·0	55·5	80·6	159·2	+ 80·2	+ 312·7	+ 6·7	+ 35·7	+ 104·3
39·0	53·3	9·3	14·3	28·9	− 2·7	+ 41·1	− 4·8	− 2·5	− 12·7
74·3	138·2	221·5	32·6	116·6	+ 28·2	+ 99·5	+ 192·2	− 14·4	+ 76·4
10·2	42·0	3·0	4·6	16·7	− 213·2	− 308·5	− 40·7	− 70·1	− 158·3
92·9	326·9	69·1	240·2	219·5	+ 55·2	+ 237·2	+ 20·0	+ 236·0	+ 175·6
62·4	52·2	69·5	25·5	52·4	+ 4·1	− 54·1	+ 13·3	− 16·3	− 18·7
44·9	132·4	68·5	93·4	94·4	− 7·7	+ 25·5	− 25·2	− 7·3	− 2·7
...	...	...	...	...	− 0·3	− 8·3	− 8·4	− 20·4	− 10·9
471·1	1249·1	483·3	607·5	702·8	− 178·7	+ 278·9	+ 113·7	+ 127·4	+ 68·8
Summary (continued).									
2860·2	2642·2	2068·0	3793·3	2841·1	+ 705·2	+ 459·8	+ 939·2	+2111·3	+1053·8
1092·7	565·7	1684·7	699·2	1010·6	+ 845·5	+ 387·4	+1537·1	+ 497·3	+ 816·9
471·1	1249·1	483·3	607·5	702·8	− 178·7	+ 278·9	+ 113·7	+ 127·4	+ 68·8
4424	4459	4236	5100	4554	+1373	+1126	+2592	+2736	+1968

according to the amount, the description, and the combination in which the nitrogen is employed. The characteristic tendency of the various mineral manures, on the other hand, is to favour consolidation or maturation rather than luxuriance, and, hence, when used alone, the competition becomes less severe, and a larger number of species is enabled to maintain a place.

The lines in the table showing the percentages of the total Gramineæ, total Leguminosæ, and total Miscellaneæ, exhibit such extremely wide ranges in their proportion to one another in the four complete separation-years, that it is difficult from the figures there given to form a definite conclusion as to the tendency of either group to increase or diminish in relative proportion. Calling to our aid the results of the partial separations made in several intermediate and succeeding years, it must be concluded that the grasses have increased in their proportion during the later years, whilst the Leguminosæ have not sustained the tendency to increase so prominently in the later as in the earlier years. It may also be said of the Miscellaneæ that the tendency with them is to decline in proportion. In actual amount per acre, too, the grasses have of late years increased, and the Leguminosæ and the Miscellaneæ diminished. Without manure, on the other hand, though the actual quantities per acre are much less than with the mineral manure, the grasses have diminished very considerably, the Leguminosæ have even increased, but the Miscellaneæ have diminished even in greater degree than with the mineral manure.

Whilst referring to the relation to one another of our three main groups, some reference should be made to the characters of the second crops in this respect. The indication is that in the second crops the percentage of Gramineæ is generally higher, and that of the Leguminosæ and Miscellaneæ lower; and this is especially the case on the mixed mineral manure plot now under consideration.

Among the grasses, *Festuca ovina* is by far the most prominent species, and is increasing; but it is, nevertheless, in by no means such excessive proportion, or amount, as on the plots with an excess of nitrogenous manure. *Agrostis vulgaris* and *Holcus lanatus* are also prominent, and, upon the whole, increasing; though the latter shows considerable fluctuation, according to season. Taking the average of the four complete separation-years, these three most prominent grasses yield collectively only about one-third of the total herbage; and, consistently with the character of comparatively little forced luxuriance of individual species, a considerable number of other grasses contributes a fair proportion to the produce. The most prominent of these, on the average, though declining, is *Avena pubescens*, then *A. flavescens*; next come *Dactylis glomerata*, *Poa trivialis*, and *Anthoxanthum odoratum*, in about equal amounts; then *Lolium perenne*, and, in smaller quantities, but still apparently maintaining some position, come *Poa pratensis*, *Avena elatior*, and *Alopecurus pratensis*.

The final column in the table further indicates the general character of the change induced by the mixed mineral manure as compared with the produce without manure. It is seen that, of *Alopecurus pratensis*, *Lolium perenne*, *Anthoxanthum odoratum*,

and a few grasses of very limited habit of growth, there was actually less with the manure than without manure; but of no fewer than 10 species there was greater or less increase with the manure. That is to say, there was comparatively little relative predominance of any particular species, but a generally increased development of the numerous plants constituting the flora of the unmanured plot, a result which is strikingly different from that obtained with the increased luxuriance induced by the application of nitrogenous manures.

Of the four Leguminosæ enumerated as found in the samples, it will be seen that, whilst *Trifolium repens*, *T. pratense*, and *Lotus corniculatus*, have contributed a decreasing, and, in the later years, a very insignificant amount, *Lathyrus pratensis* has, on the average, furnished three-fourths of the whole of the leguminous herbage; with, however, very fluctuating quantities according to season, and, as has been already alluded to, probably a decreasing amount in the more recent years. It is of interest to observe in the columns showing the increase over the unmanured produce, that there is actually less of the deep-rooting and self-reliant *Lotus corniculatus* with than without the manure, and that almost the whole of the increase is due to the comparatively shallow-rooting *Lathyrus*. It is, however, worthy of note that the partial separations of the second crops indicate a lower proportion, and scarcely any more actual produce, of the mixed leguminous herbage with the manure than without manure; and it is also significant that, in these second crops, the *Trifoliums* bear a much larger proportion to the *Lathyrus* than in the first. An examination of the samples of the partial separations leads to the conclusion that this is explained by the fact that, owing to the habit and conformation of the plants, new and stronger shoots are more freely produced from the thick-branched stock of the *Trefoils* which remain after cutting, than from the comparatively thinner and less branching stock of the *Lathyrus*, in which the relatively few shoots that are produced after cutting are of very slender and feeble character.

Among the Miscellaneæ, *Rumex Acetosa* is the most prominent on the mineral manured plot, as it was also on the ammonia plot, and on that with the larger amount of nitrate of soda. But the mineral manured plot was more favourable to *Conopodium denudatum*, and to *Achillea Millefolium*, both of which, however, fluctuated very greatly in amount, according to season. No other miscellaneous plant, except *Luzula campestris*, was in any noticeable degree of prominence. The last division of the table shows that *Plantago lanceolata*, and the various species of *Ranunculus* taken collectively, were in each year in actually less amount with the mineral manure than without manure; so also, but in a less degree, was *Pimpinella Saxifraga*, and, in two out of the four years, *Luzula campestris*.

The only plants which uniformly yielded more with the mineral manure than without manure, were *Rumex Acetosa* and *Conopodium denudatum*, *Achillea Millefolium* doing so in three out of the four years. Thus, under the conditions of maturation rather than of luxuriance, that is of tendency to consolidation of tissue, and to reproduction,

rather than to vegetation merely, the miscellaneous plants which most prominently gained ground are the thick-stocked and free-seeding *Rumex*, the tuberous-rooted *Conopodium*, and the fleshy-stocked, much branched, and also free-seeding *Achillea*. It may here be stated that in the years subsequent to the last complete separation, *Centaurea nigra* appears to be gaining ground, this being especially manifest in the second crops.

It will be observed from the foregoing enumeration that, independently of the striking increase in the growth of *Lathyrus*, which, however, would seem to be less marked in recent years, the herbage grown under the influence of mixed mineral manure, including potass, is very complex, and the distribution is very similar in general character to that without manure; the difference between the two being, with the exception of the altered relation of the different Leguminosæ, due more to a different condition of development, than to any marked distinction in the relative predominance of different orders, genera, or species.

The general appearance of the mineral manured plot is also quite characteristic. Instead of the dark colour, irregularity, and prominent leafiness, exhibited by the plants of the ammonia and the nitrate plots, there is here a lighter, healthier hue, and general evenness, with a very large proportion of fine but comparatively matured stems, intermixed nevertheless with much leafy bottom-growth. This character of stemminess, and tendency to consolidation of tissue, applies not only to the grasses, but also to the Leguminosæ and to the miscellaneous plants; among the latter, especially to the *Rumex* and the *Conopodium*, whilst the *Achillea*, being later in development, is not so markedly stemmy in the first crop, its main development of above-ground, or at least of erect-growing, stem taking place subsequently to the first cutting. These remarks apply to the first crops. The second crops show, in general, a more grassy growth than the first, with a greater predominance of fine leaf; and although usually fairly mixed, still *Festuca ovina* and *Agrostis vulgaris* are, upon the whole, the most prominent.

Notwithstanding that a characteristic of the herbage of this plot is to include a larger amount of Leguminosæ, and especially of *Lathyrus*, than any other (unless, indeed, it has been overtaken in this respect in quite recent years on plot 15, where the same mineral manure was first applied in 1876), there is no doubt that, according to the figures, there has been some decline as compared with the earlier years. Unfortunately, however, we have much less frequent determinations in the earlier than in the later years, the first being in the third season (1858), when about 23 per cent. of the total produce consisted of Leguminosæ, of which about 18 consisted of *Trifolium pratense*, and only 4½ of *Lathyrus pratensis*. The first complete separation-year was the seventh of the experiments, when the Leguminosæ contributed nearly 25 per cent. to the produce, *Trifolium pratense* now yielding less than 7, but *Lathyrus* about 13½ per cent. Five years later (1867) the total Leguminosæ were under 13 per cent. *Trifolium pratense* yielding under 5, and *Lathyrus* nearly 7 of this. In 1871 the

total Leguminosæ amounted to a little over 16 per cent. In 1872, the seventeenth year of the experiments, the Leguminosæ contributed nearly 40 per cent., *Trifolium pratense* giving little more than 1 of this, and *Lathyrus* nearly 37. Since that time the percentage of total leguminous herbage has been—under 13 in 1874, under 9 in 1875, about 9½ in 1876, 18¾ in 1877 (of which more than 12 was *Lathyrus*), 13½ in 1878, little more than 8 in 1879, and only 7½ in 1880.

It is thus obvious, not only that the Leguminosæ were very much more prominent in the earlier than in the later years, but that the deeper-rooting *Trifolium pratense* rapidly gave place to the more superficially-rooting *Lathyrus*; whilst this, in its turn, would appear to be now declining.

It has been assumed that the source of the large amount of nitrogen essential to, and taken up by, the *Lathyrus*, was the accumulation within the surface soil, which has been shown to have diminished considerably in recent years. The question arises, how far the decline in yield is to be attributed to the amount of nitrogen available from this source from year to year being, under the influence of the mineral manure (including potass) and the exhausting growth of the Leguminosæ, gradually reduced; or whether, in addition to or apart from this, there is anything in the treatment of the vegetation which would tend to lessen the recuperative power of these leguminous species. On this point it should be observed, as has been explained in detail elsewhere, that owing to the injury done to the animals when the second crops were consumed on the land by sheep without any other food being given, it became necessary to abandon the practice and to cut the aftermath instead. Thus, in 1866, 1870, 1873 (twice), 1874 (twice), and in 1876, the after-growth was cut and left on the land to decay; whilst in 1875, 1877, 1878, 1879, and 1880 the second crops were not only cut, but were removed from the land, thus considerably enhancing the tendency to exhaustion of the soil.

Taking it for granted that the reduction in leguminous growth in recent years under the influence of the continuous application of the mineral manure is not merely a temporary effect due to the characters of the seasons, but a permanent tendency set in, we may, perhaps, safely conclude that reduction in the amount of nitrogen annually available from the accumulated resources of the soil is one cause of the decline, but we may, perhaps, also assume, that the altered treatment of the second crops has not been without influence. Reference has already been made to the comparatively injurious effect of the first cutting upon the *Lathyrus*, as exhibited in the character of the second growth of that plant, and it would seem only reasonable to suppose that such injury, clearly manifest after the first cuttings, would be enhanced when the second growth is annually treated in the same way. The question suggests itself whether, as the *Trifoliums* and the *Lotus* suffer less than the *Lathyrus* by cutting, they will, in consequence, show any tendency to recover their position. There is already, perhaps a slight indication of this, so far as the *Trifolium* is concerned. But in so far as the relative prominence of the *Lathyrus* has been due to the supplies of the

surface-soil becoming available under the influence of the mineral manure, it would hardly seem probable that the deeper-rooting plants would thoroughly regain their former position.

With regard to the undoubted tendency to gradual increase, not only in the relative but in the actual amount of the grasses in recent years, the explanation may perhaps be open to question; and the evidence bearing upon it will be considered more in detail in the chemical section of our report. As has been referred to, the growth of a leguminous crop on arable land, frequently leaves the surface soil richer in nitrogen in a degree determinable by analysis; and it is known that after the removal of a highly nitrogenous leguminous crop a larger gramineous one, taking up more nitrogen than if it had succeeded another of the same description, will be obtained. It has been already suggested, whether the increased growth of the grasses here, in the mixed herbage, is due to similar conditions being induced by the increased growth of the Leguminosæ, now in association, instead of separately in alternation, with them; that is, whether it be due to a residue of combined nitrogen left after the growth of the leguminous plants in such condition of combination and distribution as to be now available for the associated gramineous ones, the subsequent growth of which is thereby enhanced. Another explanation obviously may be, that under the influence of the mixed mineral manure, including potass, the richer nitrogenous accumulations of the surface soil of the grassland itself, yield up their stores in a condition in which the Gramineæ as well as the Leguminosæ of the mixed herbage can take them up. Against this supposition is the fact, that such a potass manure will increase the growth of Leguminosæ in the poorer in nitrogen ordinary arable land, whilst it will not, in any marked degree, increase the growth of the Gramineæ on such arable land. If, therefore, the result be due to the direct liberation, in an available form, of nitrogen from the resources of the soil itself, under the influence of the mineral manure, it would seem that it must be provided in different conditions of combination for these two very distinct descriptions of herbage, and that a supply in the condition required by the Gramineæ is in a very much greater degree available from the richer in nitrogen pasture, than from the poorer in nitrogen arable, surface soil.

5. *Superphosphate of lime, alone; Plot* 4¬1.

The experiment with superphosphate of lime alone did not commence until the fourth year; sawdust alone, but without effect, having been applied in each of the first three years. It has been seen that in the case of the mixed mineral manure of plot 7, very marked results were produced, but from the complex character of the manure, it is only by comparison with those on other plots, and by other collateral evidence, that it can be decided to which of the constituents of the mixed manure the specially characteristic results were mainly due. Hence it is of considerable interest to compare the results obtained with superphosphate of lime alone with those from the mixed mineral manure, which included, besides the same amount of superphosphate, salts of potass, soda, and magnesia. In the next sub-section will be compared

the results yielded with superphosphate of lime in conjunction with salts of soda and magnesia, but without potass.

The superphosphate of lime alone yielded more gross produce, but only a little more, than was obtained without manure, and the excess was the less in the later years. Indeed, not only the actual amount of produce, but the yield per acre of both nitrogen and mineral matter declined more rapidly with the superphosphate alone than without manure. In fact, the superphosphate of lime alone yielded, over the first 17 years of its application, less than two-thirds as much produce as the mixed mineral manure, and not three-fifths as much nitrogen. It is obvious, therefore, that the results which were obtained on plot 7 were in only a very small degree due to the superphosphate which the manure supplied. Let us see how the botany of the superphosphate plot bears out this conclusion. (See Table LXIX., pp. 1332–3.)

It will be seen that the effect of the manure was, as already said, upon the whole, extremely meagre. In fact, there was scarcely any increased luxuriance induced; and such increase in produce as there was, was mainly due to an increased tendency to stem-formation and consolidation of tissue in the case of some species. There was thus but little artificial struggle induced, and we have an average of 47 species as compared with 49 without manure. Both the percentage in the total herbage, and the actual quantity per acre, of the total Gramineæ rather declined, whilst those of the Leguminosæ rather increased; and the percentage, but not the actual quantity, of the miscellaneous herbage also showed some tendency to increase.

Compared with the produce without manure, there was, however, on the average, a slight increase of gramineous, a decrease of leguminous, and an increase of miscellaneous herbage, the result being but insignificant increase of total produce.

The column showing the average increase or decrease in the yield per acre of each individual species by superphosphate of lime alone, compared with the unmanured plot 3, shows a slight increase in quantity, in the order named, of *Holcus lanatus*, *Poa trivialis*, *Avena flavescens*, *Lolium perenne*, and *Avena pubescens*, a very slight increase of *Cynosurus cristatus* and *Dactylis glomerata*, and an actual deficiency of *Briza media*, *Agrostis vulgaris*, *Alopecurus pratensis*, *Anthoxanthum odoratum*, and, though very trifling, even of *Festuca ovina*. Upon the whole, therefore, the increase is partly, though not entirely, among some of the better agricultural grasses, and as has been said, it was due rather to consolidation of tissue than to increased luxuriance or succulence; in fact, to stemmy development but with dwarf growth.

Of the Leguminosæ, *Trifolium pratense* and *Lotus corniculatus* yielded less in each separation-year than without manure. On the other hand, in the three later of the four years, *Lathyrus pratensis* gave some increase, and on the average *Trifolium repens* gave a very slight increase. Lastly, on this plot of languid competition, and coincident great variety of species, we have in the last two separation-years a small quantity of the hard-wooded, somewhat shrubby *Ononis arvensis*, which is scarcely observable on any other plot. It is also on this plot of languid competition, and on one other plot only, that fairy rings develop in any marked degree.

TABLE LXIX.—Number of Species, Percentage, Quantity per Acre,

	Number of Species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	16	15	16	16	16	...	...	...	...	...
Leguminosæ	4	4	5	5	5	...	...	...	...	...
Other Orders	26	27	28	24	26	...	...	...	...	...
Total	46	46	49	45	47	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	2·66	7·16	4·74	0·11	3·17	119·0	253·5	84·0	1·0	132·6
Alopecurus pratensis	1·32	1·94	0·86	1·40	1·38	42·9	69·1	15·2	43·2	41·6
Agrostis vulgaris	7·21	9·09	13·88	9·97	9·79	234·3	319·2	246·9	303·2	280·7
Holcus lanatus	11·92	9·16	4·71	19·35	11·28	384·4	324·3	83·5	596·3	347·6
Avena pubescens	9·42	4·97	4·09	4·03	5·62	306·4	175·9	72·5	124·3	169·9
Avena flavescens	4·12	4·28	6·00	2·47	4·24	134·0	151·5	107·0	76·4	117·5
Poa trivialis	9·10	5·60	7·79	4·72	6·80	167·5	200·0	67·1	146·0	146·2
Briza media	0·58	0·32	2·12	2·16	1·29	19·9	11·3	37·6	66·6	33·7
Dactylis glomerata	2·25	0·90	0·87	1·41	1·31	73·2	31·9	10·1	43·6	40·5
Cynosurus cristatus	0·34	0·34	1·03	0·90	0·72	11·0	12·1	18·2	24·7	20·0
Festuca ovina	10·20	19·75	20·44	16·02	16·35	331·7	692·9	362·2	495·4	445·5
Lolium perenne	9·28	3·34	2·12	4·35	5·00	301·8	116·7	58·3	134·5	169·2
None yielding 1 per cent. — Avena elatior, Poa pratensis, Festuca pratensis, Bromus mollis	1·94	0·97	0·77	0·10	0·77	63·5	33·8	13·7	3·1	32·0
Absent—Phleum pratense, Aira caryophyllea, Festuca loliacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	8·28	2·73	0·62	...	2·95	268·6	95·6	14·5	...	84·9
Total	74·96	66·25	67·03	71·79	70·16	2432·7	2367·5	1187·7	2219·5	2026·1
LEGUMINOSÆ.										
Trifolium repens	0·61	0·09	0·48	0·35	0·38	19·8	3·2	9·5	10·8	10·6
Trifolium pratense	1·45	0·17	0·11	0·30	0·61	47·2	6·0	2·0	9·2	16·1
Lotus corniculatus	0·41	1·23	3·71	0·86	1·55	13·3	43·6	65·7	26·6	37·3
Lathyrus pratensis	0·22	1·34	4·19	3·39	2·31	10·4	47·4	74·3	104·5	59·2
Ononis arvensis	...	...	0·12	0·04	0·19	...	...	2·1	1·0	0·4
Total	2·79	2·83	8·61	5·83	4·94	90·7	100·2	152·6	170·9	128·6
OTHER ORDERS.										
Ranunculus repens et bulbosus	3·87	1·29	4·16	5·84	4·29	190·9	45·7	73·7	180·6	122·7
Conopodium denudatum	0·97	2·22	1·17	0·64	1·22	31·5	82·1	20·7	19·8	38·5
Pimpinella saxifraga	0·97	3·21	1·28	1·48	1·71	28·9	113·6	22·7	45·8	52·0
Centaurea nigra	0·43	0·36	1·01	0·86	0·62	14·0	12·7	17·9	26·4	17·2
Achillea Millefolium	1·42	1·06	0·26	2·19	1·48	46·9	36·6	4·5	68·7	76·7
Plantago lanceolata	5·63	9·56	3·13	3·78	5·55	183·1	342·0	55·4	118·9	174·4
Rumex Acetosa	2·94	0·47	2·81	2·37	2·90	120·1	139·6	49·6	104·2	119·9
Lamia campestris	1·22	2·41	2·57	0·94	2·01	39·7	85·3	62·2	29·0	53·4
None yielding 1 per cent. — Ranunculus acris, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Potentium Sanguisorba, Heracleum sphondylium, Galium Aparine, G. verum, Scabiosa arvensis, Bellis perennis, Tragopogon pratensis, Leontodon hispidus, L. autumnalis, Taraxacum officinale, Hieracium Pilosella, Veronica Chamædrys, Prunella vulgaris, Ajuga reptans, Carex præcox, Ophioglossum vulgatum, Hypnum squarrosum, H. rutabulum, H. triste	1·90	3·69	1·85	2·89	2·65	61·8	130·9	32·0	89·2	78·9
Absent — Chrysanthemum Leucanthemum, Thymus Serpyllum, Scilla nutans, Spiræa Ulmaria, Cardus arvensis	...	...	...	...	...	...	...	...	...	...
Total	22·25	30·29	24·36	22·69	24·90	723·6	1072·3	431·7	701·6	732·3
SUMMARY.										
Gramineæ	74·96	66·25	67·03	71·79	70·16	2437·7	2367·5	1187·7	2219·5	2053·1
Leguminosæ	2·79	2·83	8·61	5·83	4·94	90·7	100·2	152·6	170·9	128·6
Other Orders	22·25	30·29	24·36	22·69	24·90	723·6	1072·3	431·7	701·6	732·3
Total	100·00	100·00	100·00	100·00	100·00	3252	3540	1772	3092	2914

&c., of each Species, by Superphosphate of Lime alone; Plot 4–1.

Increase + or decrease − compared with:—

Plot 3, without manure.					Plot 7, mixed mineral manure (with potass).				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
−3	0	−1	−1	−1	−3	−1	−1	−1	−1
0	0	+1	+1	+1	0	+1	+1	+1	+1
−2	−3	0	−7	−2	+4	+5	+8	+1	+4
−4	−3	0	−7	−2	+2	+4	+8	+1	+4
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 11·6	− 35·0	− 1·5	+ 37·0	− 2·0	− 16·4	+ 79·3	− 31·2	− 4·2	+ 6·8
− 34·1	−128·8	+ 6·7	+ 36·1	− 45·0	+ 27·9	+ 33·9	− 34·4	+ 18·7	+ 9·5
−112·2	− 72·8	− 19·4	− 8·7	− 53·2	− 81·4	− 33·5	−250·8	− 307·8	− 169·6
+230·6	+ 58·8	+ 34·3	+201·2	+148·4	+ 140·5	+202·2	− 50·3	− 73·0	− 41·2
+ 11·9	+ 73·6	+ 14·1	+ 60·7	+ 40·1	− 304·6	+ 2·0	− 27·5	+ 9·6	− 80·1
+ 61·6	+ 39·5	+ 50·5	+ 50·9	+ 63·2	− 43·8	− 64·3	− 48·7	− 109·7	− 66·3
+120·3	+161·0	+ 30·9	+182·3	+118·3	− 0·3	+ 4·7	− 30·3	+ 35·1	+ 9·0
− 39·9	− 11·4	− 67·6	− 104·6	− 55·5	+ 17·6	+ 9·6	+ 32·4	+ 69·7	+ 29·2
+ 19·5	− 23·0	− 4·7	+ 27·0	+ 4·7	− 40·5	−173·2	− 51·1	− 143·6	− 104·6
+ 5·9	+ 23·4	...	+ 1·5	+ 9·3	+ 7·5	+ 19·9	+ 14·4	+ 19·6	+ 15·3
− 74·3	+ 96·4	+ 6·0.	− 22·1	− 1·0	− 278·7	+ 69·5	− 267·4	− 80·7	− 239·6
+107·4	+ 51·4	+ 16·3	+ 28·9	+ 50·5	+ 163·8	+ 79·7	+ 30·2	− 19·5	+ 63·3
+ 27·3	+ 16·4	+ 9·7	...	+ 13·4	− 176·3	− 90·7	− 108·4	− 200·9	− 144·0
− 0·6	...	− 0·2	− 1·8	− 0·7	− 1·0	...	− 0·4	− 0·5	− 0·5
+ 29·3	−107·9	− 34·2	...	− 28·2	+ 140·7	− 10·4	− 67·3	...	+ 20·8
+202·7	+184·1	+ 58·9	+537·5	+262·6	− 422·5	−278·7	− 880·3	−1573·8	− 788·0
Leguminosæ (continued).									
+ 3·8	− 3·8	+ 2·3	+ 7·7	+ 2·5	− 116·4	− 17·8	− 66·8	+ 10·3	− 47·4
− 69·5	− 64·3	− 25·6	− 40·7	− 44·9	− 250·4	− 209·9	− 45·9	− 69·9	− 144·3
− 42·8	− 34·7	− 22·0	− 66·8	− 44·0	− 42·9	+ 12·8	+ 57·7	+ 24·6	+ 13·0
− 29·0	+ 24·7	+ 83·2	+ 48·5	+ 25·9	− 867·9	−254·6	−1479·6	− 513·1	− 709·5
...	...	+ 2·1	+ 19·9	+ 9·4	...	...	+ 2·1	+ 19·5	+ 9·4
−156·5	− 78·1	+ 5·0	− 31·0	− 65·1	−1007·0	−466·8	−1532·1	− 529·3	− 862·0
Other Orders (continued).									
+ 42·0	− 21·3	+ 23·4	+ 99·0	+ 36·3	+ 132·9	+ 28·8	+ 64·9	+ 164·3	+ 97·7
+ 1·9	− 16·2	− 29·1	− 23·1	− 16·4	− 84·3	−329·7	− 34·8	− 80·6	− 132·7
− 19·4	− 1·0	+ 9·6	+ 27·0	+ 4·1	+ 27·7	+ 69·1	+ 51·4	+ 31·5	+ 27·7
+ 4·3	− 7·0	− 16·7	− 4·7	− 6·0	+ 12·7	− 22·5	+ 6·5	+ 15·3	+ 2·0
− 0·5	+ 27·9	+ 68·0	+ 51·7	+ 36·3	− 29·7	− 71·7	− 126·2	+ 86·1	− 40·1
− 40·2	− 18·5	+ 11·7	+ 42·2	− 0·8	+ 173·9	+299·0	+ 52·4	+ 112·9	+ 137·7
+ 85·4	+134·9	+ 20·7	+ 60·0	+ 75·2	+ 36·2	−202·3	+ 0·7	− 236·0	− 100·6
− 18·6	− 35·0	+ 7·0	− 13·8	− 13·7	− 22·7	+ 83·1	− 6·8	+ 0·5	+ 1·0
+ 19·4	+ 35·3	− 32·5	− 7·7	+ 3·4	+ 23·1	+ 79·9	− 8·5	+ 14·7	+ 27·6
...	...	...	− 5·1	− 1·3	− 4·9	− 46·3	− 13·6	− 13·8	− 19·7
+ 72·8	+102·0	+ 64·1	+221·5	+115·3	+ 282·5	−176·8	− 51·6	− 94·1	+ 39·5
Summary (continued).									
+282·7	+184·1	+ 58·9	+537·5	+262·6	− 422·5	−278·7	− 880·3	−1573·8	− 788·0
−156·5	− 78·1	+ 5·0	− 31·0	− 65·1	−1007·0	−466·8	−1532·1	− 529·3	− 862·0
+ 72·8	+102·0	+ 64·1	+221·5	+115·3	+ 282·5	−176·8	− 51·6	− 94·1	+ 39·5
+200	+208	+129	+728	+316	−1173	−918	−3464	−2006	−1640

The Miscellaneous plants which on the average have contributed rather more to the produce than without manure are—*Rumex Acetosa*, *Achillea Millefolium*, *Ranunculus repens*, and *R. bulbosus*, and, in a very insignificant degree, *Pimpinella Saxifraga*; whilst *Conopodium denudatum*, *Luzula campestris*, and *Centaurea nigra*, actually yield less than without manure.

The general result by superphosphate of lime shows, then, comparatively immaterial change from the condition of the unmanured herbage, whilst that which is observed, is mainly due to increased maturation, and not to increased luxuriance. The general aspect of the plot is that of comparatively puny and stemmy development of freer-growing species, or the predominance of those of small habit, according to the season. In the case of the grasses, the second growth is much more characterised by a large proportion of fine-leaf than is the first; the smaller grasses predominating. Among the Leguminosæ, *Lathyrus* shows less of prominence in the second than in the first crops. Among the Miscellaneæ the chief weeds attain a greater degree of maturity.

Thus, an examination of the botany of the superphosphate plot, and a comparison of it with that without manure, fully confirms the indications of the yield of hay, of nitrogen, and of mineral matter, and shows conclusively that the striking effects, both in increased yield and in development of individual species, which were produced on plot 7, with the *mixed* mineral manure, including potass, were but little, if at all, attributable to the superphosphate of lime which that complex manure contained.

6. *Mixed mineral manure, alone, with and without potass; Plot* 8.

As the superphosphate of lime of the mixed mineral manure was obviously not the potent agent, at least when used alone, the results must be traceable to the potass, the soda, or the magnesia salt, separately or conjointly, which were employed with it. For the first six years of the experiments, plots 7 and 8 each received the same mixed mineral manure, including potass; but from that time (1862), and since, the same manure has been still annually applied to plot 7, and the same, *excluding the potass*, to plot 8; an increased amount of soda salt being used instead. From the time of this change, not only the produce of hay, but the yield of nitrogen, and of mineral matter, diminished very greatly on plot 8, now without potass. Taking the results of the partial as well as of the complete separations, it appears that the *percentage* of total gramineous herbage has been almost uniformly greater in the smaller amount of produce yielded on plot 8 without, than in the larger amount on plot 7 with the potass. Without the potass the percentage of the Leguminosæ diminished exceedingly; whilst that of the miscellaneous species collectively rather increased. The yield per acre, however, of each of the three descriptions of herbage considerably diminished after the exclusion of the potass. As referred to more fully at pp. 316, *et seq.*, of Part I., and as will be shown in detail in Part III., from the time of the cessation of the application of the potass-salt, the amount of potass annually taken up by the crop declined in an extraordinary degree; and not only so, but the amount

taken up of most of the other mineral constituents, soda and silica excepted, also declined. The percentage in the dry substance was, however, much the same in the produce of the two plots; whilst that of the potass was much less where it was not supplied, though still higher than without manure.

There is thus direct evidence of the influence of the potass of the manure on the yield, on the botany, and on the chemical composition, of the produce. But there is evidence of various kinds that there was a residue of the potass applied in the first six years, which had, at first, a considerable, and which has still, some effect on the results obtained on plot 8. Table LXX., pp. 1336–7, shows in detail the botanical composition of the herbage; and as the special point under consideration is the result as compared with that on plot 7, where the application of potass has been continued, there is given, not only the percentage botanical composition of the mixed herbage, the lbs. per acre of each species, and the increase or reduction compared with the unmanured plot 3, but also the increase or reduction in the yield of each, in each separation-year, as compared with plot 7.

It happens that 1862, the first year of complete botanical separation, was also the first year of the exclusion of the potass from the manure of plot 8, so that it is not to be expected that the results of that year will show so markedly the characteristic effects of the change as those of the subsequent periods.

Referring first to the number of species, there was in each year a less number than without manure; on the average of the four separation-years, six less. Compared with plot 7 there was a falling off in number in the first separation-year, that is in the first year of the exclusion of the potass, but a gradual increase subsequently; presumably due to a less active competition, with the less free growth, in the absence of the potass. There were, however, generally fewer species found in the samples than in those from plot 4–1, with superphosphate of lime alone, where there was still less of growth, and consequently still less of active competition.

An examination of the lines of total Gramineæ, total Leguminosæ, and total Miscellaneæ, will show that, in the second separation-year, that is after the effects of the change had become thoroughly established, there was a diminution, both in the percentage and in the yield per acre, of the grasses, a very great diminution, both in percentage and yield, of the leguminous herbage, and a greater increase in those of the miscellaneous herbage. But it will be remembered that the second separation-year was one pre-eminently favourable to a relative excess of the miscellaneous species; still, in the third and fourth separation-years, there was also a higher percentage proportion, and amount, of such herbage than in the first. There was at the same time a continued diminution in both the percentage and actual amount of the leguminous herbage; in fact, only about one-sixth as much was grown in the fourth as in the first separation-year. The total yield of the Gramineæ also diminished very much from the first to the third, but increased again considerably in the fourth separation-year. The fluctuations according to season were, indeed, very considerable. Still, especially as

TABLE LXX.—Number of Species, Percentage, Quantity per Acre, &c.,

		Number of species, and proportion per cent.					Quantity per acre.				
		1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.											
	Gramineæ	17	17	17	16	17	...	...	...	...	...
	Leguminosæ	4	4	4	4	4	...	...	...	...	...
	Other Orders	17	21	21	23	22	...	...	...	...	...
	Total	38	42	42	43	43	...	...	...	...	...
GRAMINEÆ.		p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
	Anthoxanthum odoratum	2·78	6·90	7·94	7·53	6·54	169·3	290·9	302·9	273·6	259·5
	Agrostis vulgaris	10·01	4·32	9·22	12·40	9·01	452·9	169·2	329·3	449·4	350·7
	Holcus lanatus	4·31	10·25	4·61	13·23	9·40	204·0	391·9	119·4	480·3	343·7
	Avena elatior	4·32	2·16	4·40	2·17	3·01	204·5	139·9	113·0	114·9	128·3
	Avena pubescens	12·66	3·44	3·86	1·67	5·90	573·6	131·5	94·0	60·5	214·9
	Avena flavescens	5·42	3·93	6·94	2·45	4·68	245·2	134·6	179·2	88·8	161·7
	Poa pratensis	1·72	1·80	2·11	1·03	1·66	77·8	67·4	54·3	37·3	59·7
	Poa trivialis	5·48	3·48	1·62	3·20	3·45	247·9	133·1	41·6	116·0	134·7
	Briza media	0·07	0·08	1·16	0·87	0·47	3·2	3·0	29·8	30·6	14·1
	Dactylis glomerata	2·50	1·43	0·66	2·66	1·56	139·3	54·6	16·9	95·5	66·6
	Cynosurus cristatus	0·25	0·24	1·03	1·14	0·66	11·3	9·3	26·5	41·3	22·0
	Festuca ovina	7·51	17·74	23·96	19·76	17·24	339·5	678·4	613·0	710·1	567·3
	Festuca pratensis	2·21	0·42	0·53	0·54	0·93	100·0	16·1	9·3	19·6	36·1
	Bromus mollis	1·26	0·43	0·09	2·01	0·95	57·4	16·4	2·3	0·4	20·4
	Lolium perenne	5·92	2·61	1·92	7·63	4·52	267·6	99·9	49·3	276·5	173·3
Not yielding 1 per cent.	Alopecurus pratensis, Aira cæspitosa	0·40	0·89	0·53	0·67	0·62	19·1	34·0	13·7	31·5	24·3
Absent.	Phleum pratense, Festuca loliacea	...	...	...	...	...	...	...	...	...	...
	Undetermined (chiefly Gramineæ)	2·29	2·49	1·30	...	1·54	108·2	95·3	33·3	...	59·1
	Total	71·09	69·03	71·86	81·19	71·97	3243·3	2410·5	1837·6	2942·3	2608·3
LEGUMINOSÆ.											
	Trifolium repens	2·70	0·10	0·25	0·10	0·79	122·1	3·8	6·4	2·6	34·0
	Trifolium pratense	7·71	1·13	0·27	0·36	2·37	348·8	43·2	6·9	13·0	103·0
	Lotus corniculatus	0·15	0·83	3·51	1·18	1·42	6·8	31·7	90·2	42·8	42·9
	Lathyrus pratensis	0·76	0·32	2·34	2·37	0·47	200·3	230·5	101·2	66·9	211·0
	Ononis arvensis	...	...	...	...	...	...	...	...	...	...
	Total	19·32	8·88	7·97	4·01	10·04	674·0	339·5	204·7	145·3	390·9
OTHER ORDERS.											
	Ranunculus acris	...	0·26	0·47	1·09	0·25	...	23·3	12·0	39·5	19·2
	Ranunculus repens et bulbosus	1·16	0·54	1·90	0·93	0·88	82·9	21·0	23·7	22·6	30·7
	Conopodium denudatum	1·59	0·94	1·73	1·07	2·61	71·9	261·3	44·4	38·8	104·1
	Pimpinella Saxifraga	0·91	1·91	1·05	0·87	1·11	36·6	73·1	27·0	24·3	40·2
	Achillea Millefolium	0·93	0·69	0·75	2·76	0·98	42·1	187·0	250·4	100·0	144·9
	Plantago lanceolata	0·71	1·53	0·34	0·26	0·71	32·1	59·5	8·7	9·4	27·2
	Rumex Acetosa	1·93	7·06	1·96	0·84	4·20	87·3	300·6	50·3	211·6	162·5
	Lamium cæspitosa	0·79	1·76	2·06	0·43	1·41	33·9	67·3	69·3	17·4	46·7
None yielding 1 per cent.	Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Spiræa Ulmaria, Heracleum Sphondylium, Galium verum, G. Aparine, Scabiosa arvensis, Centaurea nigra, Tragopogon pratensis, Taraxacum officinale, Veronica Chamædrys, Prunella vulgaris, Ajuga reptans, Primula veris, Carex præcox, Hypnum squarrosum, H. rutabulum, H. bleue	1·11	2·09	1·51	1·26	1·49	50·3	80·1	39·9	71·9	60·3
Absent	Potorium Sanguisorba, Bellis perennis, Chrysanthemum Leucanthemum, Leontodon hispidus, Hieracium Pilosella, Thymus Serpyllum, Scilla autumn, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
	Total	9·99	19·09	20·47	14·99	19·09	466·7	1074·2	855·7	836·4	635·6
SUMMARY.											
	Gramineæ	71·09	69·03	71·86	81·19	71·97	3243·3	2410·5	1837·6	2942·3	2608·3
	Leguminosæ	19·32	8·88	7·97	4·01	10·04	674·0	339·5	204·7	145·3	390·9
	Other Orders	9·99	19·09	20·47	14·99	19·09	466·7	1074·2	855·7	836·4	635·6
	Total	100·00	100·00	100·00	100·00	100·00	4384	3824	2548	3924	3635

of each Species, by Mixed Mineral Manure, without Potass; Plot 8.

Increase + or decrease − compared with:—																				
Plot 5, without manure.					Plot 7, mixed mineral manure (with potass).					Plot 4-1, superphosphate, alone.										
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.						
Number of Species (continued).																				
− 1	+2	0	−1	0	−1	+1	0	−1	0	+1	+2	+1	0	+1						
0	0	0	0	0	0	0	0	0	0	0	0	0	−1	−1						
−11	−3	−7	−3	−6	−5	−1	+1	+5	0	−9	−6	−7	+4	−4						
−12	−1	−7	−4	−6	−6	0	+1	+4	0	−8	−4	−7	+3	−4						
Gramineæ (continued).																				
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.						
+ 37·7	− 21·6	+118·4	+ 183·6	+ 71·8	+ 32·9	+ 21·7	+ 88·7	+ 111·4	+ 91·2	+ 49·3	+ 19·4	+119·9	+116·0	+ 74·0						
+ 100·2	−122·3	− 39·0	+ 133·6	+ 23·2	+137·0	− 89·8	− 287·1	− 163·6	− 89·1	+ 219·4	− 85·0	− 6·6	+144·2	+ 70·5						
+ 50·2	+128·4	+ 58·2	+ 383·6	+ 149·9	− 19·9	−134·6	− 15·4	− 19·9	− 49·1	− 180·4	+ 67·6	+ 34·3	+ 61·0	− 9·9						
+ 302·4	+113·9	+116·9	+ 113·7	+ 136·2	+ 97·9	+116·2	+ 93·5	+ 49·1	− 89·7	+ 259·3	+114·5	+110·3	+113·4	+124·6						
+ 179·1	+ 29·2	+ 35·6	− 3·1	+ 85·2	− 37·4	− 42·4	− 6·0	− 54·2	− 35·0	+ 267·2	− 44·4	+ 21·5	− 63·6	+ 45·1						
+ 172·8	+ 72·6	+132·9	+ 63·3	+ 107·4	+ 67·4	− 51·2	+ 30·6	+ 97·3	− 22·4	+ 111·2	− 16·9	+ 70·3	+ 12·4	+ 44·7						
+ 68·9	+ 51·7	+ 82·7	+ 33·6	+ 82·3	+ 27·8	+ 10·6	+ 42·0	− 32·0	− 13·9	+ 59·6	+ 49·3	+ 86·2	+ 36·7	+ 47·7						
+ 200·9	+ 94·1	+ 32·4	+ 102·8	+ 107·8	+ 79·3	− 62·2	− 55·8	+ 9·4	− 7·5	+ 80·1	− 66·9	− 25·5	− 30·0	− 10·5						
− 54·5	− 19·7	− 75·4	− 136·6	− 71·1	+ 1·9	+ 0·3	+ 23·6	+ 13·3	+ 10·3	+ 15·7	− 9·3	− 7·8	− 46·2	− 19·6						
+ 104·6	− 1·4	+ 2·1	+ 16·9	+ 31·3	+ 44·6	−151·6	− 54·3	− 15·7	− 79·3	+ 21·6	+ 6·9	− 6·1	− 9·1	+ 3·3						
+ 6·1	+ 4·9	+ 8·0	+ 12·1	+ 9·3	− 7·5	− 0·8	+ 22·4	+ 30·2	+ 16·4	+ 0·3	− 20·5	+ 8·0	+ 16·0	+ 1·1						
− 99·1	+177·9	+258·3	+ 146·2	+ 120·8	−267·6	+171·0	+ 14·8	− 640·0	−187·8	+ 9·1	+ 89·8	+252·3	+220·7	+141·8						
+ 36·5	+ 16·1	+ 9·3	+ 19·4	+ 20·7	+ 92·5	− 12·4	+ 3·8	+ 29·6	+ 12·6	+ 20·6	+ 7·1	+ 19·0	+ 19·0	+ 16·4						
+ 59·4	+ 14·7	+ 2·1	+ 0·4	+ 19·9	+ 0·7	− 27·1	+ 0·6	− 0·1	− 4·9	+ 45·5	+ 1·2	+ 0·7	+ 0·0	+ 11·9						
+ 73·4	− 34·5	+ 10·3	+ 16·9	+ 16·5	+129·8	− 7·2	+ 24·3	+ 122·5	+ 67·3	− 34·0	− 35·9	− 6·0	+142·0	+ 4·0						
− 119·2	−139·9	+ 3·0	+ 23·5	− 62·7	+ 2·6	− 5·2	− 36·3	+ 9·5	− 8·2	− 24·5	− 31·1	− 1·5	− 11·7	− 17·9						
− 0·3	...	− 0·7	− 0·7	− 0·5	− 0·5	...	...	...	− 0·4	...	...	...	...	...						
− 131·1	−109·2	− 19·4	...	− 64·9	− 19·7	− 11·7	− 39·5	...	− 23·0	− 160·4	− 1·3	+ 19·8	...	− 35·6						
+1088·2	+239·9	+726·8	+1260·3	+ 821·0	+383·1	−232·9	−230·4	− 851·0	−232·8	+ 805·6	+ 42·8	+648·9	+722·8	+555·2						
Leguminosæ (continued).																				
+ 106·9	− 2·2	+ 0·2	+ 0·5	+ 25·9	− 14·1	− 17·2	− 68·6	+ 2·1	− 24·2	+ 102·3	+ 0·6	− 2·1	− 7·2	+ 23·4						
+ 212·1	− 27·1	+ 20·7	− 30·4	+ 32·0	+ 46·2	−168·7	− 41·0	− 66·1	− 57·4	+ 301·6	+ 37·2	+ 4·9	+ 3·8	+ 56·9						
− 49·1	− 40·6	− 7·5	− 55·6	− 38·4	− 49·4	+ 0·9	+ 62·2	+ 40·9	+ 13·6	− 0·3	− 11·9	+ 24·3	+ 10·2	+ 5·6						
+ 357·9	+238·1	+ 55·1	+ 29·9	+ 177·7	−201·4	− 41·2	−1452·6	− 551·7	−856·7	+ 385·9	+213·4	+ 26·9	− 19·6	+151·9						
...	...	...	...	...	...	...	...	...	...	...	...	− 2·1	− 19·5	− 5·4						
+ 626·2	+161·2	+ 87·1	− 86·6	+ 197·2	−218·7	−226·2	−1480·0	− 553·9	−819·7	+ 783·3	+239·3	+ 52·1	− 23·6	+262·3						
Other Orders (continued).																				
− 0·3	+ 25·0	+ 10·8	+ 29·3	+ 19·7	− 2·5	+ 20·0	+ 2·9	+ 20·6	+ 10·3	− 1·0	+ 21·8	+ 9·9	+ 31·5	+ 15·3						
− 98·4	− 46·0	− 22·6	− 58·1	− 55·7	− 5·5	+ 4·1	+ 16·8	+ 7·2	+ 5·7	− 138·4	− 24·7	− 49·0	−157·1	− 92·0						
+ 82·3	+163·0	− 2·4	− 0·1	+ 49·2	− 17·9	−149·7	− 12·1	− 41·6	− 55·1	+ 49·4	+179·2	+ 23·7	+ 19·0	+ 65·6						
− 10·1	− 41·5	+ 12·9	+ 5·5	− 8·3	− 1·4	+ 19·6	+ 17·7	+ 10·0	+ 11·4	+ 9·3	− 45·5	+ 4·3	− 21·9	− 12·4						
− 4·6	+148·3	+221·1	+ 53·0	+ 104·5	− 32·8	+ 48·8	+ 28·9	+ 67·4	+ 28·1	− 4·1	+129·3	+155·1	+ 1·3	+ 69·2						
− 191·9	−299·0	− 35·0	− 62·3	− 147·8	+ 21·9	+ 9·5	+ 8·7	+ 4·8	+ 10·5	− 151·0	−283·5	− 40·7	−107·5	− 147·2						
+ 44·6	+ 241·9	+ 21·2	+ 167·4	+ 118·8	− 5·6	− 90·3	+ 1·2	− 126·6	− 57·6	− 49·8	+ 107·0	+ 0·3	+ 107·4	+ 42·6						
− 24·4	− 53·0	+ 12·1	− 24·4	− 22·4	− 28·5	+ 13·1	− 1·2	− 9·1	− 5·7	− 9·9	− 19·0	+ 9·1	− 8·6	− 6·7						
+ 0·4	− 2·9	− 30·7	+ 3·4	− 8·0	+ 14·6	− 11·3	− 8·5	+ 2·5	− 0·7	− 4·1	− 8·3	− 5·4	+ 0·1	− 3·2						
− 2·7	− 29·9	− 29·5	− 53·6	− 30·2	− 5·7	− 35·7	− 11·0	− 5·1	− 14·4	− 20·4	− 51·1	− 4·5	− 35·5	− 27·9						
− 243·1	+103·9	+158·1	+ 58·3	+ 19·3	− 64·4	−174·9	+ 42·4	− 71·1	− 67·0	− 310·9	+ 1·9	+ 94·0	−165·2	− 95·5						
Summary (continued).																				
+1088·2	+239·9	+726·8	+1260·3	+ 821·0	+383·1	−232·9	− 230·4	− 851·0	−232·8	+ 805·6	+ 42·8	+648·9	+722·8	+555·2						
+ 626·2	+161·2	+ 87·1	− 86·6	+ 197·2	−218·7	−226·2	−1480·0	− 553·9	−819·7	+ 783·3	+239·3	+ 52·1	− 23·6	+262·3						
− 243·1	+103·9	+158·1	+ 58·3	+ 19·3	− 64·4	−174·9	+ 42·4	− 71·1	− 67·0	− 310·9	+ 1·9	+ 94·0	−165·2	− 95·5						
+1472	+492	+924	+1260	+1037	+100	−634	−1668	−1476	−919	+1272	+284	+796	+332	+721						

shown by the intermediate and recent partial separations, the tendency to decrease in total yield of Graminеæ, to decrease in a greater degree (in proportion to their amount) in the yield of the Leguminosæ, and to decrease somewhat in that of the miscellaneous species also, cannot be doubted. The most prominent and unquestionable of all these results was, however, the great and continuous decline in leguminous growth after the exclusion of the potass.

Looking to the particulars relating to the individual species, the first point to note is the large number of species, especially of the grasses, contributing fairly to the yield, and the comparatively small number asserting very marked predominance, these being the indications of languid struggle. Among the grasses, *Festuca ovina* and *Holcus lanatus* are the only species which have very obviously gained ground; the latter, however, showing considerable fluctuation from one separation-year to another. *Agrostis vulgaris* has also yielded a comparatively large proportion, and has, upon the whole, increased in relative amount. The meagre-growing *Anthoxanthum odoratum*, though giving a less average percentage than any of the foregoing, has, nevertheless, continuously increased.

Among the grasses which have the most obviously diminished in percentage are, *Avena pubescens*, which has done so the most strikingly of all, *Poa trivalis*, *Dactylis glomerata*, *Festuca pratensis*, and *Bromus mollis*; *Lolium perenne* doing so up to the third separation-year, but afterwards regaining ground. Those which have shown comparative indifference, fluctuating from season to season without any very obvious tendency, independently of season, either to increase or diminish, are *Avena elatior*, *Avena flavescens*, and, though occurring in much smaller amount, *Poa pratensis*.

Comparing the actual yield per acre with that without manure, it is seen that, among the grasses yielding more than one per cent. to the herbage, there was, on the average, and almost uniformly in detail, an increased amount of every species, excepting *Briza media*, which alone was in each separation-year in less quantity than without manure. The grasses which give the largest increase compared with the unmanured plot are *Holcus lanatus*, *Festuca ovina*, *Avena elatior*, *Avena flavescens*, and *Poa trivialis*. It is thus obvious that the conditions, either owing to the constituents still supplied, or to the residue of the previous applications of potass, were still favourable to an increased growth of Graminеæ.

Compared with the produce of plot 7, with the continuous application of potass, there are, on the other hand, nine grasses that give, on the average, less on plot 8, and only six which give, on the average, more; the balance as to total quantity being considerably and increasingly against plot 8. Indeed, if the results of the first separation-year—that is, of the first year of change—were not included in the general mean, the result would be very much more strikingly against plot 8, as compared with plot 7, in the yield of grasses. As the table stands, the grasses which yield actually more without than with the potass are *Avena elatior*, *Anthoxanthum odoratum*, *Lolium perenne*, and, in much less degree, *Cynosurus cristatus*, *Festuca pratensis*, and

Briza media; whilst those which are the most prominently reduced on plot 8 are *Festuca ovina*, *Agrostis vulgaris*, *Dactylis glomerata*, *Holcus lanatus*, and, in a less degree, *Avena pubescens*, *Avena flavescens*, *Poa pratensis*, *Poa trivialis*, and *Bromus mollis*.

On the other hand, as compared with plot 4–1, with superphosphate of lime alone, plot 8, with its continuous supply of soda and magnesia, and its residue from previous applications of potass, in addition to the superphosphate, yielded, on the average, more, and sometimes considerably more, of almost every gramineous species, the excess being the most prominent in the case of *Festuca ovina* and *Avena elatior*.

The results of the complete separations show (and the fact is fully borne out by observation in other years) that the great reduction in leguminous herbage, consequent on the exclusion of the potass, is mainly due to a greatly reduced growth of *Lathyrus pratensis*, but also to a decreased growth of *Trifolium pratense* and *Trifolium repens*; whilst, though in less amount than without manure, there is on plot 8, compared with plot 7, even a slight increase in the yield of the deep-rooting, self-reliant *Lotus corniculatus*. In fact, it will be found throughout the experiments that the Leguminosæ are only specially favoured by purely mineral manures containing potass, and that, under the influence of such comparatively superficial supply of potass, it is the *Lathyrus pratensis* which becomes by far the most prominent.

As has been said, the proportion in the mixed herbage of the collective miscellaneous species has been, upon the whole, increased since the exclusion of the potass; but, as with the grasses and the Leguminosæ, the yield per acre of the Miscellaneæ has declined compared with plot 7, though there is still an excess compared with plot 3 without manure. The miscellaneous species which have maintained the greatest prominence throughout are *Rumex Acetosa* and *Achillea Millefolium*, *Conopodium* coming next in this respect; but there has been very great fluctuation in the proportion and amount of collective and individual miscellaneous species from year to year, according to season. In the first separation-year (1862), there was a small proportion and amount of the collective Miscellaneæ, and no one individual species was in marked excess. In the second separation-year there was more than three times as high a percentage, and more than two and a-half times as much actual yield, of such produce, *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium* each being in excessive amount. In the third separation-year there was less percentage, and only about half as much actual yield, as in the second; and now *Achillea Millefolium* yielded nearly half the total miscellaneous herbage, and no other species was very specially prominent. Lastly, in the fourth separation-year, with a fair total amount, *Rumex Acetosa* contributed about two-fifths of the whole, *Achillea Millefolium* about one-fifth, and no other species any material amount. Taking the average of the four separation-years, the order of prominence in actual yield among the Miscellaneæ on plot 8 was as follows: *Rumex Acetosa*, *Achillea Millefolium*, *Conopodium denudatum*, and in much less quantity, *Luzula campestris*, *Pimpinella Saxifraga*, *Ranunculus repens* and *bulbosus*, *Plantago lanceolata*, and *Ranunculus acris*.

Compared with the produce without manure, plot 8 gave in each separation-year a greater or less excess of *Rumex Acetosa*, and in three out of the four years of *Achillea Millefolium*; whilst in each year it gave considerably less of *Plantago lanceolata*, and, in a less degree, of *Ranunculus repens* and *bulbosus*.

Compared with plot 7 (the result, therefore, being due to the exclusion of potass), *Achillea Millefolium*, *Plantago lanceolata*, *Pimpinella Saxifraga*, and the various species of *Ranunculus* were generally in excess, whilst *Rumex Acetosa* and *Conopodium denudatum* were mostly in reduced amount.

Lastly, compared with the results by superphosphate of lime alone, plot 8 gave, on the average, some excess of *Achillea Millefolium*, *Conopodium denudatum*, *Rumex Acetosa*, and in less degree of *Ranunculus acris*; but a considerable deficiency of *Plantago lanceolata* and of *Ranunculus repens* and *bulbosus*, and, to some extent, of *Pimpinella Saxifraga* and *Luzula campestris*.

Upon the whole, the produce by the mixed mineral manure, including potass during the earlier years, but excluding it during the greater part of the total period, has presented fairly even growth, with considerably mixed herbage; and, since the exclusion of the potass, both restricted luxuriance and maturation as compared with plot 7, and a gradual but very marked diminution in the proportion and amount of the Leguminosæ, especially of the more superficially-feeding *Lathyrus pratensis*; *Lotus*, on the other hand, having increased.

Among the Grasses a large number contributed to the herbage, and although *Agrostis vulgaris*, *Festuca ovina*, and *Holcus lanatus* are in the highest relative pro minence, each has considerably reduced in actual yield since the exclusion of the potass, as also have *Dactylis glomerata* and a number of others in less degree; whilst plants of such opposite characters as *Avena elatior*, *Anthoxanthum odoratum*, and even *Lolium perenne*, have increased in actual yield as compared with their produce on plot 7.

Among the Miscellaneæ the most prominent, though each very variable in amount from year to year according to season, are *Achillea Millefolium*, *Rumex Acetosa*, and *Conopodium denudatum*, the first being in excess of the amount on plot 7, the other two considerably in defect.

Lastly, comparing the results without manure, with superphosphate of lime alone, with the mixed mineral manure including potass, and with the same excluding potass, it is manifest that the effects, both as to quantity and to botanical and chemical composition, are more dependent upon the supply of the potass than of any of the other constituents.

One more striking point in regard to the botany of this plot is that it is here, where there is no nitrogenous manure to induce luxuriance, and where there is relative deficiency of potass, that, as on plot 4–1, where there was equally no nitrogenous supply and less potass still, fairy-rings are of very frequent occurrence, whilst they are scarcely observed on any other plot; and this is so notwithstanding the fact

that fungi are among the most highly nitrogenous of plants, and are also very rich in potass. The principal fungus met with on the rings is the common Champignon, *Marasmius oreades;* and the grass of the rings is extremely luxuriant, the species most favoured being *Poa trivialis* and *Holcus lanatus;* whilst among the Leguminosæ *Lathyrus pratensis* is the most prominent, and among the Miscellaneæ *Rumex Acetosa* and *Conopodium denudatum* are particularly luxuriant. On the comparatively exhausted space within the rings every description of herbage is much less luxuriant, and the finer-leaved grasses again become more predominant. Further particulars on this subject will be found in a note by one of us, "On the Occurrence of Fairy-rings," Jour. Linn. Soc. (1875), Botany, vol. 15, p. 17, *et seq.;* and the chemical aspects of the question will be further treated of in the chemical section (Part III.) of our report.

7. *Ammonia-salts* (400 *lbs. per acre*), *with mixed mineral manure, including potass; Plot* 9.

Thus far we have considered the results obtained without manure, by various nitrogenous manures alone, and by various mineral manures alone. We have now to call attention to those yielded by mixtures of the nitrogenous and mineral manures. Among these the first to consider are the effects produced by a mixture of the same description and amount of ammonia-salts as were used alone on plot 5, and the same mixed mineral manure (including potass) as was used alone on plot 7. Accordingly, in the table (LXXI., pp. 1342–3), besides the percentage of each species, its produce per acre, and its greater or less amount than without manure, in each separation-year, there is given the increase or decrease of each species, in each separation-year, compared with the corresponding results obtained, on the one hand on plot 5 with the ammonia-salts alone, and on the other on plot 7 with the mixed mineral manure alone. It should also be stated that there has been no change in the manuring of either of these three plots from the commencement.

With the mixture of both nitrogenous and mineral manure there was more than twice as much produce as without manure, nearly twice as much as with ammonia-salts alone, and nearly one and a half time as much as with the mineral manure alone. There was some falling-off in the later compared with the earlier years of the first 20, though in a less degree than with the ammonia-salts alone; whilst with the mineral manure alone there was increase rather than diminution. With the mixture, however, there was, during the next five years, a higher rate of produce, even of first crops, than during the first 20, notwithstanding that in the later years the second crops have been removed from the land. With the nitrogen supplied in conjunction with minerals there was a considerably greater yield of nitrogen in the produce than with either the ammonia-salts alone, or the mixed mineral manure alone; and of mineral matter taken up per acre, there was more than twice as much as with the ammonia-salts alone, and considerably more than with the mineral manure alone. In a word, with the combination of both nitrogenous and mineral manure, there was more hay,

TABLE LXXI.—Number of Species, Percentage, Quantity per Acre, &c., of each Species,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Graminea	13	14	16	13	14	...	...	...	...	...
Leguminosæ	2	2	1	4	2	...	...	...	...	...
Other Orders	13	13	13	10	12	...	...	...	...	...
Total	28	29	30	27	28	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	1·24	3·59	2·23	2·94	2·51	79·4	183·2	127·3	179·0	144·5
Alopecurus pratensis	0·27	0·07	2·76	0·96	1·01	17·3	3·6	156·7	58·2	58·9
Agrostis vulgaris	12·91	12·43	12·46	12·23	12·46	820·1	722·6	674·7	740·4	739·5
Holcus lanatus	13·14	9·94	7·61	10·37	9·99	777·2	529·6	430·5	627·8	591·3
Avena elatior	...	2·50	11·40	12·23	6·78	...	134·6	645·0	801·0	393·1
Avena pubescens	10·22	1·41	0·49	0·07	3·04	654·3	78·9	27·7	4·3	190·6
Avena flavescens	9·09	3·78	5·30	0·67	4·71	561·3	203·4	299·8	40·5	281·2
Poa pratensis	10·68	12·02	22·67	19·13	16·16	683·7	700·7	1282·7	1091·5	939·7
Poa trivialis	2·72	2·14	2·84	0·11	2·20	556·2	115·2	96·2	6·7	113·1
Dactylis glomerata	5·58	4·94	11·58	14·07	9·04	357·2	249·7	672·2	851·8	532·8
Festuca ovina	5·21	19·42	9·63	21·90	13·56	333·5	991·4	491·1	1319·8	784·0
Festuca pratensis	1·42	0·07	0·03	...	0·38	90·9	3·9	1·7	...	24·1
Bromus mollis	4·46	0·11	0·10	...	1·17	285·5	5·9	5·7	...	74·3
Lolium perenne	4·20	1·01	1·11	0·16	1·62	268·9	54·8	62·9	9·7	99·9
None yielding 1 per cent. { Aira caspitosa, Briza media, Cynosurus cristatus	...	...	0·02	0·01	0·02	...	...	1·2	0·6	0·3
Absent—Phleum pratense, Festuca bulbosa.	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Graminea).	2·86	2·03	1·79	...	1·84	184·9	142·1	101·3	...	107·1
Total	86·59	77·06	92·19	84·65	88·12	5571·6	4147·4	5216·1	5730·2	5191·3
LEGUMINOSÆ.										
Trifolium repens	0·01	0·01	...	...	0·01	0·8	0·5	...	...	0·3
Trifolium pratense	...	...	...	0·01	0·01	...	...	...	0·6	0·1
Trifolium minus	...	...	...	0·01	0·01	...	...	...	0·6	0·1
Lathyrus pratensis	0·12	0·15	0·02	0·06	0·08	7·7	8·1	1·1	3·6	5·3
Ononis arvensis	...	...	...	0·33	0·07	...	...	...	20·0	4·0
Lotus corniculatus	...	...	...	...	...	...	...	...	...	...
Total	0·13	0·16	0·02	0·41	0·18	8·5	8·6	1·1	24·9	10·7
OTHER ORDERS.										
Compositæ dandatum	2·22	2·25	1·51	0·75	1·62	139·9	103·2	83·4	45·4	105·2
Achillea Millefolium	1·95	2·03	1·50	0·04	1·37	124·9	109·3	84·3	2·4	80·2
Rumex Acetosa	5·40	10·39	4·60	2·60	6·12	345·7	556·2	260·2	218·0	352·5
None yielding 1 per cent. { Ranunculus repens et bulbosus, Stellaria graminea, Potentilla reptans, Spiræa Ulmaria, Pimpinella saxifraga, Heracleum Sphondylium, Galium verum, Scabiosa arvensis, Centaurea nigra, Tragopogon pratensis, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Scilla nutans, Ornithogalum umbellatum, Luzula campestris, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triste.	1·01	0·51	0·18	0·55	0·59	64·7	27·3	10·4	33·2	34·9
Absent { Ranunculus acris, Cerastium triviale, Agrimonia Eupatoria, Poterium Sanguisorba, Galium Aparine, Bellis perennis, Chrysanthemum Leucanthemum, Leontodon hispidus, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Ophioglossum vulgatum.	...	...	...	...	...	...	...	...	...	...
Total	11·29	23·79	7·79	4·94	11·70	722·1	1226·0	440·8	299·0	672·0
SUMMARY.										
Graminea	86·59	77·06	92·19	84·65	88·12	5571·6	4147·4	5216·1	5730·2	5191·3
Leguminosæ	0·13	0·16	0·02	0·41	0·18	8·5	8·6	1·1	24·9	10·7
Other Orders	11·28	22·79	7·79	4·94	11·70	722·1	1226·0	440·8	299·0	672·0
Total	100·00	100·00	100·00	100·00	100·00	6402·0	5382·0	5658·0	6054·0	5874·0

by 400 lbs. Ammonia-salts, with Mixed Mineral Manure, including Potass; Plot 9.

Increase + or decrease − compared with :—

Plot 3, without manure.					Plot 5, ammonia-salts alone.					Plot 7, mixed mineral manure (with potass) alone.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.

Number of Species (continued).

− 5	− 1	− 1	− 4	− 3	− 4	−1	+1	0	−1	− 5	− 2	− 1	− 4	− 3
− 2	− 2	− 3	0	− 2	− 2	−3	−2	+2	−1	− 2	− 2	− 3	− 5	− 2
−15	−11	−15	−21	−16	− 4	−4	0	−4	−3	− 9	− 9	− 7	−13	−10
−22	−14	−19	−25	−21	−10	−7	−1	−2	−5	−16	−13	−11	−17	−15

Gramineæ (continued).

lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 81·3	− 85·2	+ 41·9	+ 57·0	− 11·9	− 143·9	+ 11·9	+ 30·9	+ 57·3	− 2·9	− 86·9	+ 19·0	+ 12·1	+ 18·3	− 2·5
+− 119·7	− 109·1	+ 147·7	+ 51·1	− 27·7	− 7·7	− 11·7	+ 130·4	+ 51·4	+ 4·9	+ 2·3	− 89·4	+ 106·6	+ 23·7	+ 29·3
+ 473·4	+ 435·3	+ 609·4	+ 426·3	+ 486·1	− 116·4	+ 29·5	+ 209·5	− 129·3	− 2·7	+ 504·2	+ 469·1	+ 376·3	+ 127·4	+ 369·7
+ 422·4	+ 284·1	+ 371·3	+ 231·1	+ 327·5	+ 289·7	+ 242·3	+ 362·9	+ 138·9	+ 417·5	+ 553·3	+ 71	+ 286·7	− 43·4	+ 202·5
− 7·1	+ 127·6	+ 542·9	+ 726·8	+ 392·0	− 151·4	+ 42·7	+ 607·6	+ 794·2	+ 522·2	− 106·2	+ 131·9	+ 625·5	+ 726·2	+ 346·9
+ 850·8	− 26·4	− 30·7	− 59·4	− 66·4	+ 372·6	+ 55·1	+ 21·7	+ 0·7	+ 112·5	+ 42·3	− 98·0	− 72·3	− 110·5	− 59·4
+ 606·9	+ 141·4	+ 242·4	+ 18·0	+ 228·9	+ 542·3	+ 132·2	+ 226·2	+ 49·2	+ 362·9	+ 453·4	− 12·4	+ 142·2	− 142·8	+ 36·9
+ 674·8	+ 690·0	+1281·2	+1069·8	+ 860·2	+ 642·5	+ 672·2	+1767·4	+1044·7	+ 919·5	+ 632·7	+ 653·9	+1185·5	+1002·2	+ 868·1
+ 511·3	+ 76·3	+ 28·0	− 6·5	+ 152·3	+ 523·8	+ 100·3	+ 21·4	+ 6·4	+ 164·2	+ 389·7	− 80·1	− 61·2	+ 100·9	+ 36·9
+ 403·5	+ 191·7	+ 657·4	+ 335·2	+ 497·0	+ 285·1	+ 203·7	+ 684·8	+ 756·9	+ 469·9	+ 243·5	+ 41·5	+ 601·0	+ 694·4	+ 387·7
− 72·4	+ 404·9	+ 134·9	+ 802·3	+ 317·4	− 514·0	− 19·2	− 679·4	− 253·9	− 366·5	− 272·9	+ 484·0	− 138·4	− 29·2	+ 6·9
+ 89·7	+ 2·8	+ 1·5	− 0·2	+ 23·7	+ 77·4	− 0·6	+ 1·2	...	+ 19·5	+ 83·4	− 24·7	− 3·0	+ 48·4	+ 1·8
+ 281·3	+ 4·2	+ 2·5	...	+ 72·8	+ 262·4	+ 4·9	+ 5·7	...	+ 72·5	+ 229·8	− 37·6	+ 2·0	− 0·5	+ 49·0
+ 74·3	− 80·0	+ 52·6	− 87·9	− 19·8	+ 140·8	+ 14·3	− 89·2	+ 7·0	+ 16·1	+ 130·9	− 52·7	+ 37·6	− 144·3	− 7·1
− 63·2	− 27·0	− 132·4	− 194·9	− 102·0	− 3·1	− 0·6	+ 0·8	...	− 0·9	− 3·3	− 12·5	− 7·2	− 12·1	− 9·5
− 0·3	...	...	− 0·7	− 0·3	...	...	...	...	...	− 0·5	...	...	...	− 0·1
− 76·3	− 41·4	+ 52·6	...	− 16·0	+ 31·0	+ 109·8	+ 77·5	...	+ 54·6	+ 30·1	+ 58·1	+ 39·5	...	+ 32·0
+3518·6	+1964·0	+4087·3	+4048·2	+3404·0	+2344·8	+1772·0	+3088·8	+2953·5	+2539·2	+2811·4	+1504·2	+3149·1	+1336·9	+2350·2

Leguminosæ (continued).

− 19·6	− 6·5	− 6·2	− 3·1	− 7·3	+ 0·2	+ 0·2	− 0·3	...	...	− 133·6	− 20·5	− 78·0	− 0·5	− 57·9
− 136·7	− 70·3	− 27·6	− 42·3	− 70·9	− 1·5	− 0·3	...	+ 0·6	− 0·3	− 302·6	− 211·9	− 47·9	− 78·5	− 160·3
...	...	...	+ 0·6	+ 0·1	...	...	...	+ 0·6	+ 0·1	...	...	...	+ 0·6	+ 0·1
− 40·3	− 70·2	− 26·6	− 69·3	− 76·1	+ 6·9	+ 7·8	+ 0·1	+ 2·1	+ 4·3	− 590·0	− 293·9	− 1552·7	− 614·0	− 762·5
...	...	...	+ 20·0	+ 5·0	...	...	...	+ 20·0	+ 5·0	...	...	...	+ 20·0	+ 5·0
− 39·4	− 22·7	− 16·1	− 56·0	− 33·3	− 1·9	− 10·3	− 10·3	− 4·1	− 9·7	− 56·2	− 30·6	− 8·0	− 2·0	− 24·9
− 239·9	− 169·7	− 146·5	− 177·1	− 152·0	+ 3·7	− 2·6	− 10·5	+ 19·2	+ 2·4	−1084·4	− 557·1	−1682·6	− 674·4	− 899·9

Other Orders (continued).

+ 137·3	+ 404·9	+ 30·6	+ 0·5	+ 150·3	+ 142·6	+ 313·6	+ 89·3	+ 26·2	+ 135·5	+ 97·1	+ 92·2	+ 29·9	− 35·2	+ 46·0
+ 79·1	+ 70·6	+ 55·5	− 44·6	+ 39·9	+ 72·5	+ 73·1	+ 39·4	+ 2·3	+ 55·8	+ 49·5	+ 39·9	+ 126·7	+ 30·2	+ 39·5
+ 302·0	+ 527·5	+ 231·1	+ 173·8	+ 308·9	− 6·9	+ 59·2	+ 81·0	+ 135·1	+ 72·1	+ 252·8	+ 190·3	+ 211·1	− 122·2	+ 133·0
− 447·3	− 702·6	− 206·9	− 230·0	− 396·9	− 8·6	− 135·7	− 130·7	− 47·3	− 80·6	− 137·0	− 233·9	− 127·3	− 98·4	− 148·4
− 19·3	− 42·7	− 45·2	− 80·3	− 47·1	− 1·2	− 9·7	− 0·8	− 2·4	− 2·0	− 11·8	− 42·8	− 19·5	− 25·5	− 24·8
+ 72·3	+ 235·7	+ 73·2	− 181·1	+ 52·0	+ 199·5	+ 309·6	+ 67·7	+ 129·3	+ 175·8	+ 251·0	− 23·1	− 42·5	− 309·0	− 30·8

Summary (continued).

+3518·6	+1964·0	+4087·3	+4048·2	+3404·0	+2344·8	+1772·0	+3088·8	+2953·5	+2539·2	+2811·4	+1504·2	+3149·1	+1336·9	+2350·2
− 239·9	− 169·7	− 146·5	− 177·1	− 152·0	+ 3·7	− 2·6	− 10·5	+ 19·2	+ 2·4	−1084·4	− 557·1	−1682·6	− 674·4	− 899·9
+ 72·3	+ 235·7	+ 73·2	− 181·1	+ 52·0	+ 199·5	+ 309·6	+ 67·7	+ 129·3	+ 175·8	+ 251·0	− 23·1	− 42·5	− 309·0	− 30·8
+3350	+2030	+4014	+3690	+3276	+2548	+2076	+3144	+3102	+2717	+1978	+ 924	+1422	+ 954	+1319

more nitrogen, and more mineral matter removed, than with either description of manure used separately; but whilst with the mineral manure alone there was, in the later years, an increase rather than a diminution in all three items of yield, there was with the combination, at any rate within the first 20 years, a diminution in all, but in a much less degree than with the nitrogenous manure alone. An adequate conception of these differences can, however, only be attained on a detailed comparison of the botany of the respective plots as affected by the very characteristically different descriptions of manures.

The first point to remark is the very great reduction in the number of species under the influence of this mixed nitrogenous and mineral manure (Table LXXI., pp. 1342–3). Compared with plot 3 without manure, and taking the four separation-years, there is an average of three fewer species of grasses, two fewer of Leguminosæ, and as many as 16 fewer of miscellaneous plants; or of 21 less total number of species found in the samples. The number only varied from 27 to 30 in the four separation-years, and averaged only 28; whilst, without manure, there was an average of 49. Compared with plot 5 with ammonia-salts alone, there was on the average, and almost in every individual instance, a slight reduction in the number of species of each description of herbage; and there were, on the average of the four separation-years, five fewer species with the mixture than with the ammonia-salts alone. Compared with the results on plot 7 with the mixed mineral manure alone, there was, with one exception, a reduced number of species of each description of herbage in each separation-year. The average reduction was of grasses three, of Leguminosæ two, and of miscellaneous species 10; or, in all, an average of 15 fewer species by the addition of the ammonia-salts to the mineral manure.

A glance at the lines of totals in the table will show that the herbage became almost exclusively gramineous under the influence of the luxuriance induced by the nitrogenous manure, and the tendency to stem-formation and maturation favoured by the associated mineral constituents. Thus, in the last separation-year nearly 95 per cent. of the mixed herbage was referable to gramineous species, not half a per cent. to Leguminosæ, and not 5 per cent. to Miscellaneæ.

Taking the average of the four separation-years there was, in fact, nearly three times as much gramineous herbage per acre as without manure, nearly twice as much as by the ammonia-salts alone, and not far from twice as much as with the mineral manure alone. Reckoned in the same way, there was, on the average, not much more than one-twentieth as much leguminous herbage as without manure, rather more than with ammonia-salts alone, and only about one-hundredth as much as with the mineral manure alone. Turning to the total miscellaneous species a little more is yielded on the average by the mixed nitrogenous and mineral manure than without manure, about one-third more than by the ammonia-salts alone, but even less than by the mineral manure alone.

Looking to the record of the percentage of the individual gramineous species in the

total mixed herbage, *Poa pratensis* is perhaps the most uniformly predominating, *Festuca ovina* and *Agrostis vulgaris* coming next in this respect; the one or the other being relatively the more prevalent in the different separation-years according to the characters of the season. A number of other grasses have, however, generally contributed a fair proportion to the herbage; thus, *Holcus lanatus* has yielded a considerable average percentage and actual amount, *Dactylis glomerata* about the same average proportion, but with more tendency to increase, *Avena elatior* also has shown considerable tendency to increase, whilst *Anthoxanthum odoratum* has yielded a small but not greatly varying quantity, and *Alopecurus pratensis* less still. On the other hand, whilst *Poa pratensis* has much increased in both percentage and actual amount, *Poa trivialis* has, in a considerably greater degree, diminished, in fact almost become excluded; and, whilst *Avena elatior* has greatly increased, *A. pubescens* and *A. flavescens* have each very greatly diminished, indeed almost disappeared. Of the other grasses which have gone down in this struggle among free, luxuriantly-growing, stem-forming, and maturing species, are *Bromus mollis*, *Lolium perenne*, and in much smaller actual quantity *Festuca pratensis*.

Under the influence of such gramineous luxuriance, as already said, the Leguminosæ occurred in most insignificant amount, so much so that it is of little interest to go into any detail as to which of such species was the most persistent and prominent. *Lathyrus pratensis* was so, indeed, but in most immaterial quantity each year. *Ononis arvensis*, which may be designated as a weed, gave, however, the largest, though a very small percentage and actual quantity, in the last separation-year. There was, on the average of the four separation-years, only between 10 and 11 lbs. of total leguminous herbage per acre—a quantity which gives to its occurrence on the plot an almost accidental character.

The division of the table relating to the Miscellaneæ shows that under the conditions of luxuriant growth of the grasses on this plot, only three species of the miscellaneous group come under the category of those yielding more than one per cent. to the total herbage in any one of the separation-years. These are, in the order of their average prevalence, *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium*. Each of these varied considerably in amount from year to year according to the character of the season; but each of the three gave by far the most in the second separation-year, which, it will be remembered, was extremely favourable for Miscellaneæ generally; indeed, in that year the quantity both of *Rumex* and of *Conopodium* was extremely large. In each of the other years the *Rumex* gave more than the other two together. In fact, it is obvious that the conditions were, notwithstanding the severe competition of the free-growing grasses, very specially favourable for this vigorous, free-seeding, and objectionable weed.

In actual yield, each of these three most prominent of the miscellaneous species gave much more, on the average, than without manure, especially the *Rumex*; but of the numerous species, taken collectively, none of which have yielded one per cent. to the

total herbage, there was much less growing on this plot of great luxuriance of grasses than without manure. Compared with the yield of the three prominent species by ammonia-salts alone, the mixture gave considerably more, especially of *Conopodium denudatum*; and compared with the produce from the mineral manure alone, the mixture gave an excess of *Rumex Acetosa*, a less excess of *Conopodium denudatum*, an actual deficiency of *Achillea Millefolium*, and also a considerable deficiency of those species taken collectively, each of which only occurred in fractional quantity.

Upon the whole, then, the mixture of nitrogenous and mineral manure has given a produce characterised by great luxuriance of gramineous species, by an almost total exclusion of Leguminosæ, and by the considerable prevalence of only very few miscellaneous species, representing three very distinct natural orders: the *Polygonaceæ*, the *Umbelliferæ*, and the *Compositæ*, the species themselves being of very marked, as well as of very different, characters of growth.

The general aspect of the plot was also very distinct from that of either of the plots with which it is compared. Not only was the herbage almost exclusively gramineous, but the grasses were very luxuriant, generally developing broad leaves and strong stems, with considerable tendency to consolidation of tissue and to flowering, seeding, and maturation. The total absence of Leguminosæ, and of most of the usually prevalent Miscellaneæ, only two or three of which show any degree of prominence, also give to the appearance of the plot a marked character. Indeed, the herbage is too exclusively gramineous, and too coarse, to constitute even moderately good hay.

8. *Ammonia-salts* (400 *lbs. per acre*), *with mixed mineral manure including potass, and* 2000 *lbs. cut wheat straw; Plot* 13.

The mixture annually supplied to this plot contained precisely the same description and amount of ammonia-salts, and precisely the same complex mineral manure, including potass, as that applied to plot 9, but with 2000 lbs. of cut wheat straw in addition. The object was to try the effect of silica, and of carbonaceous organic matter, supplied somewhat in the same condition as in dung. The straw would, of course, contain a certain amount of other mineral constituents besides silica, and the amount annually supplied contained also about 9 lbs. of nitrogen. Undoubtedly, however, the manurial constituents of the straw would be for the most part very slowly available.

Compared with plot 9 without the straw, plot 13 with it gave an average of several hundred pounds more produce per acre annually; and, like plot 9, it has yielded rather more during the last five years than during the first 20. Over the 20 years, and probably since, plot 13 has yielded more mineral matter, and more nitrogen, per acre per annum; in fact, more of each individual mineral constituent than plot 9, especially of potass and phosphoric acid. Of silica, plot 13 furnished rather less in the later than in the earlier years; but whilst in the earlier years the two plots yielded practically the same amount, the amount annually taken up fell off in the later years very considerably on plot 9, but much less on plot 13; so that the increased yield of silica

over plot 9 was all in the later years. Over the 20 years, however, the excess of silica, taken up where the straw was used, was only about one-eighth as much as it would contain; and the fact that the excess was all in the later years is consistent with the supposition that the silica of the straw would be only very gradually available. A similar argument applies to the increased assimilation of nitrogen, which was much more in the later than in the earlier years.

An examination of the comparative botany of the two plots will afford useful evidence in aid of the explanation of these results.

The Table LXXII., pp. 1348–9, shows the percentage of each species at each separation, the produce per acre, the increase over that without manure; and, finally, the increase or decrease over that on plot 9 with the same manure, excepting the straw.

As with the ammonia-salts and mineral manure without the straw, so with it, we have, but even in a greater degree, a very marked reduction in the number of species found in the samples. We have, on the average, three fewer Gramineæ, two fewer Leguminosæ, and 18 fewer Miscellaneæ, in all 23 fewer species, than without manure; and there are two fewer Miscellaneæ than on plot 9 without the straw. The average number of species found on plot 13 has been 26, instead of 49 without manure; and the range in the several separation-years has been from 30 in the first (1862), to 22 only in the last (1877).

With the straw, the average percentage of Gramineæ in the total herbage is higher, that of Leguminosæ equally low, and that of Miscellaneæ lower, than without it. With the straw the highest average percentage of Gramineæ was more than 95 in the third separation-year, and it was 91 taking the average of the four years. The highest average percentage of Leguminosæ was also in the third separation-year, but it did not then reach to one-third, and averaged less than one-fifth, of 1 per cent. The highest percentage of Miscellaneæ was 13·56, in the second separation-year, the lowest 4·29, in the third year, and the average 8·77.

Compared with the unmanured plot 3, there was an average of more than 4000 lbs. per acre per annum excess of Gramineæ, of nearly 200 lbs. deficiency of Leguminosæ, and a small deficiency of total Miscellaneæ also. Compared with plot 9, there were between 600 and 700 lbs. average increase of gramineous herbage, practically the same average amount of leguminous herbage, but a deficiency of total miscellaneous.

Looking to the composition of the herbage in more detail, it is to be observed that this almost exclusively gramineous produce was characterised by containing a very large and increasing percentage of *Dactylis glomerata*. Next in order, but with less than half the average quantity, came *Agrostis vulgaris*, which was in fairly uniform amount throughout, and next *Poa pratensis* in less, but in increasing proportion. Though yielding less average quantities than the foregoing, *Avena elatior* and *Alopecurus pratensis* have gained ground in a marked degree; whilst *Poa trivialis*, instead of increasing, as did *Poa pratensis*, has in a striking degree diminished, indeed, almost disappeared. *Avena pubescens*, *Avena flavescens*, and *Festuca pratensis*, have

TABLE LXXII.—Number of Species, Percentage, Quantity per Acre, &c., of Potass, and 2000 lbs.

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	14	15	15	14	14	...	...	...	...	...
Leguminosæ	3	2	3	0	2	...	...	...	...	...
Other Orders	13	8	10	8	10	...	...	...	...	...
Total	30	25	28	22	26	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	0·69	1·89	0·42	0·33	0·83	43·7	112·8	29·1	20·5	51·5
Alopecurus pratensis	3·26	4·53	5·89	6·78	5·14	210·2	274·8	388·7	419·9	323·4
Agrostis vulgaris	12·72	20·24	19·44	19·40	14·90	753·3	1243·3	927·7	941·2	941·4
Holcus lanatus	5·35	4·70	2·71	4·57	4·33	339·1	280·7	195·1	286·6	276·4
Avena elatior	0·42	2·49	9·17	11·08	5·79	26·1	147·6	647·7	686·9	379·8
Avena pubescens	5·45	0·59	0·14	0·22	1·86	340·1	35·5	10·0	1·2	96·7
Avena flavescens	4·84	4·27	1·72	1·56	2·85	306·3	256·8	122·0	96·9	181·0
Poa pratensis	3·91	10·25	11·44	1·09	6·92	243·6	612·4	772·9	629·5	564·4
Poa trivialis	11·83	6·66	2·11	0·64	5·31	749·2	412·0	154·7	39·9	338·9
Dactylis glomerata	27·89	20·28	43·05	40·75	32·99	1765·4	1240·8	3090·7	2565·1	2165·4
Festuca ovina	2·27	6·82	3·60	3·57	4·06	142·6	406·2	237·4	222·2	252·1
Festuca pratensis	3·86	0·87	0·06	0·03	1·13	245·8	54·7	3·3	1·6	71·4
Lolium perenne	2·75	1·21	0·16	0·11	1·06	175·4	72·3	11·3	6·8	66·7
None yielding 1 per cent.	0·63	0·09	0·11	0·11	0·24	39·8	4·7	7·5	6·5	14·7
Absent	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	5·12	1·61	1·28	...	2·03	325·5	99·0	86·2	...	129·9
Total	90·43	86·32	95·39	92·04	91·04	5706·1	5235·4	6694·7	5773·7	5852·5
LEGUMINOSÆ.										
Trifolium repens	0·04	0·03	0·01	...	0·02	2·1	1·8	0·3	...	1·0
Trifolium pratense	0·03	...	0·01	...	0·01	1·6	...	0·6	...	0·6
Trifolium minus	...	...	...	...	...	...	...	...	...	...
Lathyrus pratensis	0·23	0·09	0·29	...	0·15	14·5	5·4	19·2	...	9·8
Ononis arvensis	...	...	...	...	...	...	...	...	...	...
Lotus corniculatus	...	...	0·01	...	0·01	...	...	0·4	...	0·1
Total	0·30	0·12	0·32	...	0·19	18·2	7·2	20·7	...	11·5
OTHER ORDERS.										
Conopodium denudatum	1·39	0·04	0·68	1·02	2·91	125·6	487·1	48·6	63·6	180·7
Achillea Millefolium	1·24	1·46	0·62	0·01	0·83	83·6	92·7	41·9	0·6	53·8
Rumex Acetosa	5·48	3·86	2·73	0·94	4·71	346·7	232·3	189·7	439·1	300·4
None yielding 1 per cent.	0·48	0·20	0·27	0·09	0·30	27·8	11·8	17·4	5·0	15·6
Absent	...	...	...	...	...	...	...	...	...	...
Total	9·27	13·56	4·29	7·96	8·77	583·7	821·4	294·6	502·3	550·5
SUMMARY.										
Gramineæ	90·43	86·32	95·39	92·04	91·04	5706·1	5235·4	6694·7	5773·7	5852·5
Leguminosæ	0·30	0·12	0·32	...	0·19	18·2	7·2	20·7	...	11·5
Other Orders	9·27	13·56	4·29	7·96	8·77	583·7	821·4	294·6	502·3	550·5
Total	100·00	100·00	100·00	100·00	100·00	6308	6064	7010	6276	6414

Gramineæ: None yielding 1 per cent.: Ranunculus acris, R. repens et bulbosus, Stellaria graminea, Cerastium triviale, Potentilla reptans, Pimpinella Saxifraga, Heracleum Sphondylium, Anthriscus sylvestris, Galium verum, Centaurea nigra, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Prunella vera, Scilla nutans, Luzula campestris, Carex præcox, Hypnum squarrosum, H. rutabulum, H. biana.

Gramineæ: Absent: Agrimonia Eupatoria, Potarium Sanguisorba, Galium Aparine, Scabiosa arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Ophioglossum vulgatum.

each Species, by 400 lbs. Ammonia-salts, with Mixed Mineral Manure, including cut Wheat-straw; Plot 13.

Increase + or decrease − compared with:—

Plot 3, without manure.					Plot 9; as plot 13, but without straw.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 4	0	− 2	− 3	− 3	+1	+1	−1	+1	0
− 1	− 2	− 1	− 4	− 2	+1	0	+2	−4	0
−15	−16	−18	−23	−18	0	−5	−3	−2	−2
−20	−18	−21	−30	−23	+2	−4	−2	−5	−2
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 86·9	− 179·7	− 56·4	− 100·5	− 104·9	− 35·7	− 80·4	− 98·2	− 157·5	− 93·0
+ 72·2	+ 80·9	+ 339·2	+ 412·7	+ 226·8	+ 192·9	+ 271·0	+ 232·5	+ 361·9	+ 264·5
+ 406·6	+ 365·8	+ 662·4	+ 527·3	+ 490·5	− 68·3	+ 329·5	+ 53·0	+ 190·8	+ 151·9
+ 183·3	+ 15·2	+ 135·9	− 19·1	+ 81·6	− 438·1	− 248·9	− 230·4	− 341·2	− 315·9
+ 24·0	+ 140·6	+ 648·6	+ 695·7	+ 376·5	+ 28·1	+ 13·0	+ 2·7	− 104·1	− 16·6
+ 45·6	− 98·9	− 49·4	− 82·4	− 33·0	− 314·2	− 60·4	− 17·7	− 2·0	− 93·6
+ 253·9	+ 186·8	+ 65·6	+ 10·4	+ 126·7	− 275·0	+ 55·4	− 176·8	− 4·6	− 100·2
+ 234·7	+ 606·7	+ 770·8	+ 627·2	+ 560·0	− 440·1	− 88·3	− 510·4	− 462·0	− 375·3
+ 702·3	+ 373·0	+ 146·5	+ 26·7	+ 312·6	+ 190·9	+ 296·6	+ 119·5	+ 33·2	+ 150·0
+1711·7	+1182·6	+3075·9	+2548·5	+2129·6	+1408·2	+ 990·9	+2419·5	+1713·2	+1632·6
− 263·3	− 100·3	− 118·4	− 295·3	− 194·4	− 186·9	− 885·2	− 253·7	−1097·6	− 581·9
+ 244·6	+ 34·7	+ 8·1	+ 1·4	+ 71·6	+ 154·3	+ 30·9	+ 1·6	+ 1·6	+ 47·3
− 19·0	− 61·0	− 27·7	− 100·4	− 52·1	− 93·5	+ 19·0	− 51·5	− 2·9	− 32·2
+ 30·0	− 1·3	− 11·1	− 17·6	...	− 245·7	− 1·2	+ 1·2	+ 5·9	− 59·8
− 57·7	− 22·7	− 106·2	− 172·1	− 89·4	...	...	− 0·6	...	− 0·1
+ 86·2	− 106·5	+ 47·3	...	+ 6·8	+ 161·5	− 69·1	− 5·1	...	+ 22·8
+3551·1	+3062·0	+5868·9	+4091·7	+4065·2	+ 34·5	+1068·0	+1478·6	+ 43·5	+ 661·2
Leguminosæ (continued).									
− 14·1	− 5·2	− 5·9	− 3·1	− 7·1	+ 1·5	+ 1·3	+ 0·3	...	+ 0·7
− 135·1	− 70·3	− 29·8	− 49·4	− 70·4	+ 1·6	...	+ 0·8	− 0·6	+ 0·5
...	...	...	...	...	...	...	...	− 0·6	− 0·1
− 32·9	− 17·3	+ 9·1	− 56·0	− 23·5	+ 0·3	− 2·7	+ 19·1	− 3·6	+ 4·6
...	...	...	...	...	...	...	...	− 32·0	− 8·0
− 56·9	− 78·3	− 97·3	− 93·4	− 81·2	...	...	+ 0·4	...	+ 0·1
− 229·0	− 171·1	− 126·9	− 201·9	− 182·2	+ 9·9	− 1·4	+ 19·6	− 24·8	+ 0·9
Other Orders (continued).									
+ 96·0	+ 388·3	− 0·2	+ 18·7	+ 125·9	− 61·3	− 16·1	− 38·3	+ 18·2	− 24·5
+ 30·9	+ 50·5	+ 12·6	− 46·4	+ 19·4	− 41·2	− 20·1	− 42·9	− 1·6	− 26·5
+ 304·0	+ 174·8	+ 159·6	+ 398·9	+ 259·7	+ 1·0	− 352·9	− 71·5	+ 215·1	− 52·1
− 429·9	− 731·6	− 214·8	− 274·9	− 429·8	+ 9·2	+ 2·3	+ 9·9	− 16·7	+ 1·3
− 4·2	− 31·2	− 30·5	− 84·2	− 32·6	− 46·1	− 17·9	− 2·9	− 11·5	− 19·7
− 69·1	− 148·9	− 73·0	+ 22·2	− 66·5	− 138·4	− 404·6	− 146·2	+ 209·3	− 121·5
Summary (continued).									
+3551·1	+3062·0	+5868·9	+4091·7	+4065·2	+ 34·5	+1068·0	+1478·6	+ 43·5	+ 661·2
− 229·0	− 171·1	− 126·9	− 201·9	− 182·2	+ 9·9	− 1·4	− 146·2	− 24·8	+ 0·9
− 69·1	− 148·9	− 73·0	+ 22·2	− 66·5	− 138·4	− 404·6	+ 209·3	− 121·5	
+3253	+2732	+5398	+3913	+3816	− 94	+ 662	+1352	+ 222	+ 540

also gone down very much. *Lolium perenne*, occurring in smaller amount, has also declined. The grasses which have shown but little decided tendency either to increase or decrease are *Festuca ovina* and *Anthoxanthum odoratum*, the latter being, however, in very small amount.

But it is a consideration of the actual yield per acre rather than of the percentage, and the comparison of the amounts with those without manure, and with the nitrogenous and mineral manure without the straw, that bring out the change in the herbage the most strikingly.

There was, on the average, 2165 lbs. of *Dactylis glomerata* annually contributed to the produce, nearly the whole of which was in excess of the yield of the same grass without manure. There was an average of 941 lbs. of *Agrostis vulgaris*, about two-thirds of which was in excess of that yielded without manure. There was an average of 564 lbs. of *Poa pratensis*, all but a fraction of which was in excess of that without manure. There was also a notable excess of *Avena elatior*, *Poa trivialis*, *Alopecurus pratensis*, and *Avena flavescens*; but there was an actual deficiency of *Festuca ovina*, *Anthoxanthum odoratum*, and a few other grasses.

The comparison with plot 9, however, brings out the most prominently the difference in the botanical composition of the herbage without and with the straw.

In the last column of the table it is seen that there was, on the average of the four separation-years, 1633 lbs. more *Dactylis* with than without the straw. There was also an average increase, but much less marked, of *Alopecurus pratensis*, *Poa trivialis*, *Agrostis vulgaris*, and *Festuca pratensis*; whilst there was a deficiency, with the straw, of more than 500 lbs. of *Festuca ovina*, a large deficiency of *Poa pratensis* (instead of excess, as of *P. trivialis*), also of *Holcus lanatus*, and a less one of *Avena flavescens*, *A. pubescens*, *Anthoxanthum odoratum*, and *Lolium perenne*; a small deficiency of *Avena elatior*, and collectively of *Phleum pratense*, *Aira cæspitosa*, *Cynosurus cristatus*, and *Bromus mollis*. Thus, the grass which is in very marked excess with the straw is *Dactylis glomerata*, whilst *Alopecurus pratensis*, *Poa trivialis*, and *Agrostis vulgaris* are also notably in excess. The grasses so brought into prominence are all free-growing, and three out of the four of good agricultural repute. On the other hand, the grasses most notably in relative defect are, *Festuca ovina*, *Poa pratensis*, and *Holcus lanatus*, whilst the several species of *Avena*, and *Anthoxanthum odoratum*, are also in decreased amount. Compared with the grasses which have become more prominent, several of those which have diminished are plants of more limited growth. The *Festuca ovina* especially, which is in the greatest degree in defect, is comparatively very superficial-rooted and fine-leaved. In fact, the most striking character is the enormous increase of *Dactylis*, and the very large diminution of *Festuca ovina*.

With regard to the Leguminosæ, the yield on both plots, 13 as well as 9, is so small that the differences are of little moment; but, so far as the figures go, the conditions seem to be rather more favourable for *Lathyrus pratensis* on the plot with the straw.

As on plot 9, so on plot 13, the only three miscellaneous plants which have contributed as much as 1 per cent. to the mixed herbage in any one year, and which were

in relative prominence in the order named, are *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium*. There was, however, on the average, and in almost every case excepting in the last separation-year, a deficiency of each on the straw plot compared with plot 9 without straw; *Rumex*, however, gave a marked excess with the straw in the last, though the excess was much less than was the deficiency in the second separation-year.

Upon the whole, then, the plot with the straw has given somewhat more produce, a larger percentage and actual amount of gramineous herbage, a great excess of *Dactylis*, and a fair excess of a few other grasses, with a considerable deficiency of *Festuca ovina* and several other Graminæ. The Leguminosæ have been scarcely affected, but the Miscellaneæ have, upon the whole, diminished in amount, though the same species are prominent as on the plot without the straw.

The general characters and aspect of this luxuriant grassy herbage were those of tufted habit, broad leaves, large stems, and considerable tendency to flowering and seeding, these characters being developed in a greater degree than on the plot without the straw. The herbage, in fact, like that of plot 9, although composed of a fair proportion of grasses of good repute, was far too stemmy and coarse to constitute good hay.

The question obviously arises—what was the explanation of the marked change in quantity, but especially in the relative predominance, of different species, and also in the character of development of the herbage on plot 13, with the straw?

As already intimated, the straw contained some nitrogen, some of most of the mineral constituents required, a great excess of silica, and a large amount of carbonaceous organic matter; but all of these would, presumably, become only slowly available, and consistently with this the relatively greater amount of produce was much more manifest in the later years. It can hardly be to the gradually available increased supplies of food that the whole of the effects are to be attributed.

As referred to in Part I., plot 13 was somewhat earlier shaded from the afternoon sun than was plot 9, and it adjoins plot 12, part of which is supposed to have been "made ground." But neither does the earlier shade seem sufficient to account for the effects produced, nor did the observations of the sections of the soil when sampling plot 13 indicate anything abnormal in its condition as they did on plot 12. Further, a consideration of the exact circumstances of the experiment, and its results, would seem to lead to more natural explanations.

Observation showed that, probably owing to the mulching effect of the straw chaff, and the consequent protection from the effects of spring frosts, there was a more active growth of young foliage quite early in the spring, and the question arises whether it is due to this that the grasses which have asserted the greater prominence owe their relatively favourable position in the struggle. With reference to this point, observations made on the plots have shown that occasionally when *Dactylis* has suffered from early frost, then the other grasses have come to the front. The usually great prevalence of *Dactylis* on plot 13 seems, therefore, to be reasonably attributable, at any rate in some degree, to protection in the early stages of its growth. Assuming this to be so, and

that the result was the establishment of a few freer-growing, and the retardation of more meagrely-developing species, we have obviously, in the fact of the predominance of plants of greater feeding and growing capacities, conditions suited to the gathering up of more food, even with the same supplies; whilst, this being the case, the comparatively small increased supply would not be without its influence. In other words, the increased produce on the plot, and the increased accumulation of nitrogen, silica, and mineral constituents generally, is not to be referred exclusively to the increased supply of constituents from without, but largely to the special conditions favouring the development of species having a greater power of food collection, and therefore a greater power of growth.

9. *Ammonia-salts* (800 *lbs. per acre*), *and mixed mineral manure, including potass; Plots* 11–1 *and* 11–2.

It has been shown that on plots 9 and 13, with the mixed mineral manure (including potass), and 400 lbs. of ammonia-salts per acre per annum, the herbage became extremely prominently gramineous, and was, upon the whole, coarse and stemmy. Still, it seemed desirable to determine whether or not the limit of growth attainable with the soil in question, and with average seasons, was reached, and to ensure that this limit should be secured. Accordingly, on plot 11, with the same mineral manure as on plot 9, double the quantity of ammonia-salts, that is 800 lbs. per acre per annum, supplying on the average about 172 lbs. of nitrogen (see p. 1305), was applied. During the first three years, however, this appearing from the results to be excessive, the quantity of ammonia-salts was reduced to one-half, that is, to the same as on plot 9; but the results obtained indicating that the limit of possible growth was not reached, the quantity was again doubled, and the double application has been continued up to the present time.* After the first six years, three with the double, and three with the single amount of ammonia-salts, and when it was decided again to use the double quantity, the plot was divided, one half, 11–1, having besides the ammonia-salts the same mineral manure as before; and the other, 11–2, the same, with the addition of artificial silicates of soda and lime for nine years, and afterwards of silicate of soda alone.

Compared with plot 9, there was a considerable increase of hay produced, and of nitrogen taken up, on the plots 11, with increased amount of ammonia salts; and in each item there was more increase on 11–2 with the silicates than on 11–1 without. There was, too, with the silicates, a less falling off in hay, and in mineral matter taken up, and a greater increase in the nitrogen gathered, over the later than over the earlier years. And, although there was less increase of herbage produced for the second increment of ammonia-salts applied than for the first, yet there was a greater proportion of the nitrogen supplied recovered in the increase. That is to say, the

* Note, January, 1883.—The above was written in 1881; for the crop of 1882 the quantity of ammonia-salts was reduced from 800 to 600 lbs.

percentage of nitrogen was relatively, indeed abnormally, high; or, in other words, less carbon was assimilated in proportion to the nitrogen accumulated. This might be due to a deficiency of available mineral matter, or to a limitation of the climatal characters for more active carbon assimilation, or partly to the one and partly to the other.

These several points are considered in Part I. (pp. 327–332), and will be discussed in their chemical aspects in Part III.; but an examination of the actual and comparative botanical characteristics of the plots will contribute useful data to the discussion.

In Table LXXIII., pp. 1354–5, will be found for plot 11–1, with the mixed mineral manure and the double quantity of ammonia-salts each year (excepting in the fourth, fifth, and sixth), the percentage of each species at the different separations, the produce of each per acre, the increase of each over the unmanured plot 3, and also the increase over plot 9, with the mineral manure and the smaller quantity of ammonia-salts.

With still more forced luxuriance than on plot 9, we have at the same time a still greater reduction in the number of species. Taking the average of the four separation-years, we have, compared with the produce without manure, five fewer Gramineæ, three fewer Leguminosæ, and as many as 22 fewer Miscellaneæ; or, in all, 30 fewer species. There was, indeed, on 11–1 an average of only 19 species against 49 without manure; and the number diminished in the four separation-years from 28 to 18, 16, and to 15 only in 1877. Compared with plot 9 even, there was an average reduction of two Gramineæ, one Leguminosæ, and six Miscellaneæ: in all, of nine species.

With the excessive luxuriance of individual species, and consequently greatly reduced numbers, the herbage is still more exclusively gramineous, the percentage of grasses reaching nearly 99 in 1872, and, on the average, nearly 95. Leguminosæ were scarcely represented at all. Again, only three Miscellaneæ yielded more than 1 per cent. to the produce in any one year, and these were the same as were persistent on plots 9 and 13, viz.: *Rumex Acetosa*, *Conopodium denudatum* and *Achillea Millefolium*; and they are in relative prominence in the same order as on those plots, but each in smaller and decreasing quantity. Thus, in the first separation-year there was more than 10 per cent. of total Miscellaneæ; in the second, not 6; in the third, little over 1; in the fourth, not 2½; and, on the average, only 5 per cent.

Among the grasses, though considerably fluctuating in amount, and in much smaller quantity in the last separation-year than previously, *Dactylis glomerata* gave by far the highest average percentage in the produce. Indeed, in the second and third of the four years it contributed nearly 40 per cent., less than half as much in the fourth, and the general average was about 30 per cent. This plant was, in each separation-year, in very much higher proportion than on plot 9, with half the quantity of ammonia-salts. Next in order as to average percentage came *Agrostis vulgaris*, *Holcus lanatus*, *Alopecurus pratensis*, and *Avena elatior*; each of which showed considerable tendency to increase, especially *Agrostis*, which in the fourth separation-year yielded nearly twice as much as the *Dactylis*, and has since maintained, perhaps, the first place among its competitors. *Poa pratensis* also yielded a fair average, but in the last

TABLE LXXIII.—Number of Species, Percentage, Quantity per Acre, &c., of each Species,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	15	13	11	11	12	...	...	...	...	...
Leguminosæ	1	1	1	...	1	...	...	...	...	...
Other Orders	12	4	4	4	6	...	...	...	...	...
Total	28	18	16	15	19	...	...	...	...	...
GRAMINEÆ.										
Alopecurus pratensis	p. c. 2·90	p. c. 13·11	p. c. 12·35	p. c. 9·91	p. c. 9·34	lbs. 199·0	lbs. 702·7	lbs. 680·7	lbs. 672·3	lbs. 614·0
Agrostis vulgaris	19·17	19·27	13·56	29·20	19·80	836·1	1032·9	967·9	1944·4	1236·1
Holcus lanatus	8·92	2·86	10·33	20·29	10·85	700·1	153·2	736·6	1376·8	743·4
Avena elatior	0·77	6·55	10·41	14·96	7·66	84·7	348·9	742·4	1009·8	812·7
Avena pubescens	1·66	0·01	...	...	0·42	118·0	0·5	...	...	29·6
Avena flavescens	8·28	0·46	0·09	0·01	1·46	573·3	24·7	6·4	0·7	101·5
Poa pratensis	9·43	12·86	10·40	1·47	8·84	670·3	689·3	741·6	99·9	550·3
Poa trivialis	13·25	0·14	0·09	0·33	3·45	941·6	7·5	6·4	22·4	244·6
Dactylis glomerata	34·16	29·31	29·29	17·11	27·96	1717·3	2137·9	2901·1	1155·0	1927·1
Festuca ovina	1·46	0·50	0·36	4·15	1·62	103·8	26·8	27·1	282·0	109·9
Festuca pratensis	1·90	...	...	...	0·47	135·1	...	...	...	33·8
Bromus mollis	1·39	0·64	0·01	...	0·26	98·8	2·1	0·7	...	25·4
Lolium perenne	1·37	0·08	...	0·01	0·37	97·4	4·3	...	0·7	25·6
None yielding 1 per cent. Anthoxanthum odoratum	9·10	0·06	0·79	0·19	0·29	7·1	3·2	53·6	12·9	19·7
Absent Aira caryophyllea, Phleum pratense, Brize media, Cynosurus cristatus, Festuca bromoides.	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	2·72	0·87	1·16	...	1·18	193·3	46·6	92·7	...	80·7
Total	89·38	94·12	90·84	97·55	94·96	6353·1	5044·9	7049·3	6628·1	6269·6
LEGUMINOSÆ.										
Trifolium repens	...	...	0·01	...	0·01	...	...	0·7	...	0·2
Lotus corniculatus	...	0·01	...	...		...	0·6	...	...	0·1
Lathyrus pratensis	0·01	...	...	...		0·7	...	...	...	0·2
Trifolium prætense, T. minus, Ononis arvensis	...	...	...	...		...	...	...	...	...
Total	0·01	0·01	0·01	...	0·01	0·7	0·6	0·7	...	0·5
OTHER ORDERS.										
Compositæ dandelium	1·79	1·84	0·04	0·01	0·91	127·2	98·6	2·9	0·7	57·9
Achillea Millefolium	1·43	0·96	...	0·01	0·36	102·1	51·9	...	0·7	29·7
Rumex Acetosa	7·02	3·96	1·09	2·25	3·57	499·0	212·3	77·7	152·9	235·5
None yielding 1 per cent. Ranunculus repens et bulbosus, Pimpinella saxifraga, Heracleum Sphondylium, Centaurea nigra, Taraxacum officinale, Prunella vulgaris, Lamia campestris, Carex pracox, Ophioglossum vulgatum, Hypnum squarrosum, H. rubabulum, H. triquetrum	0·35	0·01	0·02	0·20	0·17	24·9	0·5	1·4	13·6	10·2
Absent. Ranunculus acris, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Potarium Sanguisorba, Galium Aparine, Scabiosa arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Plantago lanceolata, Veronica Chamædrys, Thymus Serpyllum, Ajuga reptans, Prunella vulgaris, Scilla nutans	...	...	...	...	...	...	...	...	...	...
Total	10·61	6·97	1·15	2·47	5·03	754·2	514·6	82·0	167·9	329·7
SUMMARY.										
Gramineæ	89·38	94·12	90·84	97·53	94·96	6353·1	5044·9	7049·3	6628·1	6269·6
Leguminosæ	0·01	0·01	0·01	...	0·01	0·7	0·6	0·7	...	0·5
Other Orders	10·61	6·97	1·15	2·47	5·03	754·2	514·6	82·0	167·9	329·7
Total	100·00	100·00	100·00	100·00	100·00	7108	5560	7131	6796	6599

by 800* lbs. Ammonia-salts, and Mixed Mineral Manure, including Potass; Plot 11–1.

Increase + or decrease − compared with:—									
Plot 3, without manure.					Plot 9, 400 lbs. ammonia-salts, and mixed mineral manure.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 3	− 5	− 6	− 6	− 5	+2	− 1	− 5	− 2	−2
− 3	− 9	− 18	− 4	− 5	−1	− 1	− 0	− 4	−1
−16	−20	−24	−27	−22	−1	− 9	− 9	− 6	−6
−22	−25	−33	−37	−30	0	−11	−14	−12	−9
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
+ 62·0	+ 508·8	+ 672·2	+ 668·4	+ 537·4	+ 191·7	+ 698·9	+ 734·5	+ 615·3	+ 555·1
+ 589·6	+ 742·4	+ 791·7	+1079·5	+ 922·7	+ 116·0	+ 310·1	+ 92·3	+1244·0	+ 440·6
+ 561·2	− 112·2	+ 677·4	+1062·1	+ 549·6	− 72·1	− 378·3	+ 306·1	+ 751·0	+ 182·1
+ 52·6	+ 238·9	+ 749·3	+1039·9	+ 509·6	− 44·7	+ 109·5	+ 97·4	+ 308·8	+ 117·6
− 176·5	− 101·8	− 58·4	− 63·6	− 100·1	− 536·3	− 79·4	− 27·7	− 4·2	− 180·9
+ 302·9	− 37·3	− 51·0	− 24·9	+ 47·5	− 208·0	− 179·7	+ 289·4	− 39·8	+ 179·4
+ 861·4	+ 623·6	+ 749·1	+ 99·2	+ 543·9	− 13·4	− 11·4	− 541·1	− 681·9	− 309·4
+ 894·6	− 81·5	− 1·8	+ 9·2	+ 217·6	+ 363·5	− 107·7	− 29·8	+ 15·7	+ 63·4
+1952·6	+2049·2	+2736·1	+1149·4	+1811·3	+1389·7	+1857·3	+2129·9	+ 511·2	+1414·9
− 302·1	− 479·7	− 329·1	− 225·5	− 336·6	− 229·7	− 964·6	− 464·0	−1037·8	− 674·1
+ 133·9	...	− 0·2	− 0·2	+ 33·4	+ 44·2	− 9·3	− 1·7	...	+ 9·7
+ 94·8	+ 0·4	+ 0·8	...	+ 23·9	− 166·7	− 9·8	− 9·0	...	− 46·9
− 97·0	− 130·0	− 89·0	− 106·9	− 93·2	− 171·3	− 50·0	− 62·8	− 9·0	− 73·3
− 132·9	− 288·2	− 80·1	− 109·0	− 137·1	− 72·3	− 190·0	− 72·3	− 165·1	− 124·9
− 62·4	− 37·0	− 123·4	− 185·2	− 102·2	...	...	− 0·6	− 0·6	− 0·3
− 46·0	− 157·9	+ 34·0	...	− 42·4	+ 29·3	− 116·5	− 18·6	...	− 26·4
+4180·1	+2861·4	+8019·3	+4849·1	+4481·3	+ 681·5	+ 897·4	+1832·2	+ 897·9	+1077·3
Leguminosæ (continued).									
− 10·3	− 7·9	− 5·4	− 3·1	− 7·9	− 0·6	− 0·5	+ 0·7	...	− 0·1
− 55·9	− 77·7	− 97·7	− 83·4	− 81·2	...	+ 0·6	...	...	+ 0·1
− 37·7	− 62·7	− 10·1	− 50·0	− 33·1	− 7·0	− 0·1	− 1·1	− 3·6	− 2·0
− 136·7	− 70·3	− 27·6	− 42·4	− 71·0	...	...	...	− 21·2	− 5·2
− 240·5	− 177·7	− 146·9	− 201·9	− 193·2	− 7·6	− 8·0	− 0·4	− 24·8	− 10·2
Other Orders (continued).									
+ 97·6	+ 0·3	− 43·9	− 44·2	+ 2·4	− 59·7	− 404·6	− 82·5	− 44·7	− 147·9
+ 145·4	− 89·8	− 39·3	− 49·3	− 18·7	− 91·7	− 166·1	− 34·9	− 1·7	− 58·6
+ 456·3	+ 153·6	− 48·6	+ 109·7	+ 191·0	+ 183·3	+ 373·9	− 182·8	+ 69·1	+ 117·0
− 248·6	− 362·5	− 169·0	− 167·4	− 236·6	+ 11·4	− 6·4	− 9·5	+ 1·5	+ 0·8
− 257·3	− 411·6	− 92·0	− 163·0	− 231·2	− 51·2	− 20·4	− 3·5	− 21·1	− 24·3
+ 104·4	− 655·7	− 288·6	− 312·2	− 287·3	+ 32·1	− 911·4	− 359·8	− 131·1	− 342·3
Summary (continued).									
+4180·1	+2861·4	+8019·3	+4849·1	+4481·3	+ 681·5	+ 897·4	+1832·2	+ 897·9	+1077·3
− 240·5	− 177·7	− 146·9	− 201·9	− 193·2	− 7·6	− 8·0	− 0·4	− 24·8	− 10·2
+ 104·4	− 655·7	− 288·6	− 312·2	− 287·3	+ 32·1	− 911·4	− 359·8	− 131·1	− 342·3
+4026	+2028	+7487	+4335	+4000	+ 706	− 22	+1473	+ 742	+ 734

* 400 lbs. only in 1856, 1860, and 1861.

separation a much diminished, proportion; whilst *P. trivialis*, yielding largely in the earlier, contributed a mere fraction in the later years. *Avena flavescens* has also gone down very much; whilst *Festuca ovina*, the prevailing grass without manure, with ammonia-salts alone, or with mineral manures alone, occurred here in very small proportion; and several other grasses were only very meagrely represented.

On 11–1, with the mineral manure and the excess of ammonia-salts, *Dactylis glomerata* has on the average contributed nearly 2000 lbs. per acre per annum, nearly the whole of which is in excess of the amount grown without manure. The plot has also yielded an average of more than 900 lbs. per acre per annum of *Agrostis vulgaris* in excess of plot 3, and in the fourth separation-year much more than this. *Holcus lanatus*, *Alopecurus pratensis*, *Avena elatior*, and *Poa pratensis*, have also each yielded, on the average, an excess of more than 500 lbs.; and, again, the *Holcus*, *Alopecurus*, and *Avena elatior*, much more in the fourth separation-year; whilst *Poa pratensis* yielded much less in that year. *Poa trivialis* also shows an average excess, due, however, entirely to a large excess in the first separation-year. Owing to the same cause (excess in the first year), *Festuca pratensis*, and *Bromus mollis*, also show some slight average excess. On the other hand, with this excessively high manuring, and considerably increased yield of a number of free-growing grasses, there was an actual deficiency of more than 300 lbs. of *Festuca ovina*, of about 100 lbs. of *Avena pubescens*, and of 93 lbs. of *Lolium perenne*, besides a deficiency of between 200 and 300 lbs. of a number of comparatively meagre-growing species taken collectively.

Compared with plot 9 with half the quantity of ammonia-salts, plot 11–1 has given an average of more than 1400 lbs. excess of *Dactylis glomerata*, but much less in the fourth year; an excess of several hundred pounds each, of *Agrostis vulgaris*, and *Alopecurus pratensis*, and of more than a hundred pounds each, of *Holcus lanatus*, and *Avena elatior;* but the excess of *Agrostis*, *Holcus*, and *Alopecurus*, was much greater in the last separation-year than on the average. There is an actual average deficiency, compared with plot 9, of nearly 700 lbs. of *Festuca ovina*, of nearly 400 lbs. of *Poa pratensis*, and of each the deficiency was very much greater in the last separation-year. There was also an average deficiency of between 100 and 200 lbs. of *Avena pubescens* and *A. flavescens*, besides some deficiency in the quantities furnished by *Bromus mollis*, *Lolium perenne*, and a few other species taken collectively; but of the two species of *Avena*, the *Bromus*, and the *Lolium*, the deficiency was much the less in the later years.

As the table shows, the occurrence of the Leguminosæ may be said to be quite immaterial—indeed, all but accidental.

Of the three most prominent Miscellaneæ, *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium*, each has gone down in a very marked degree from the earlier to the later years; *Rumex Acetosa* being, in fact, the only one which was at all fairly represented in the fourth separation-year.

Thus, with the mixed mineral manure, including potass, and an undoubtedly excessive

amount of ammonia-salts, the herbage has become almost exclusively gramineous, Leguminosæ are practically banished, and Miscellaneæ much reduced, both in number and in quantity. The grasses which have become the most prominent are of large habit and free growth, whilst those which are reduced are for the most part characteristically of an opposite description.

For a number of years *Dactylis* was by far the most prominent, *Agrostis*, *Alopecurus*, and *Poa pratensis*, coming next; but, latterly, *Dactylis* has lost ground, both *Poas* have very much reduced, and *Agrostis vulgaris*, *Holcus lanatus*, and *Avena elatior*, seem to be coming much more to the fore in the struggle.

The character of growth of the plot is essentially tufty and patchy; coarse strong seed-stems developing, with large, dark green, broad, "flag"-like leaves, and the overgrown plants are often "laid," and the crowns become more or less rotten before cutting, whilst the maturing is irregular and imperfect.

It is not surprising that, with these conditions, there is not the same amount of growth, represented by carbon-assimilation, in proportion to the nitrogen and the mineral matter taken up, as where the smaller quantity of nitrogen is used.

According to notes taken on the ground, the young plants, and perhaps those of *Dactylis*, *Festuca ovina*, and *Holcus*, more than others, are really injured by the direct action of the large application of the ammonia-salts. Indeed, it is probable that, whilst the deficient assimilation of carbon is partly due to deficient atmospheric conditions of light, heat, and moisture, and their favourable mutual adaptation to stage of growth, it is also, in part, attributable to some deficiency in the amount and capacity of the leaf surface over the total area of the plot, there being occasional blank, uncovered spaces, instead of a uniformly distributed close leafy "bottom herbage," and such plants as are prominent are forced to the extreme limit possible within the season-period of their growth, and do not attain maturity before the favourable climatic conditions for so doing have passed.

A fact of interest which should not be overlooked is that, with a high percentage of nitrogen in the produce, and a high percentage of mineral matter also, there is, at the same time, a great depth of green colour, indicating, it may be presumed, an abundant formation of chlorophyll. We have, therefore, with abundance of nitrogen, of mineral matter, and of chlorophyll, what may be called conditions of fuller potential growth; yet, in defect of the necessary climatal conditions, and, perhaps with a consequent limitation in the duration of the cycle of growth of the plants themselves, we have a deficient carbon-assimilation, in other words deficient growth over a given area.

In the next Table (LXXIV., pp. 1358–9) are given the botanical results relating to plot 11–2, which was manured precisely as 11–1 with the exception that, in the seventh year, and subsequently, artificial silicates of lime and soda, or of soda alone, were also applied. In addition to the usual particulars, the increase or decrease in actual yield per acre of each species compared with the produce on 11–1 is given.

TABLE LXXIV.—Number of Species, Percentage, Quantity per Acre, &c., of including Potass, and

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	14	14	13	11	13	...	...	...	...	...
Leguminosæ	0	0	0	0	0	...	...	...	...	...
Other Orders	7	5	5	5	5	...	...	...	...	...
Total	21	19	18	16	18	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	1·00	0·10	0·16	0·17	0·36	71·2	6·8	11·5	14·4	25·9
Alopecurus pratensis	1·50	6·33	22·65	20·11	12·65	105·8	388·0	1630·6	1709·3	866·2
Agrostis vulgaris	19·81	24·16	10·16	17·09	17·55	1339·3	1511·4	732·9	1452·7	1257·6
Holcus lanatus	7·37	4·79	10·59	19·44	10·56	524·7	299·6	757·7	1655·5	809·4
Avena elatior	9·40	4·33	12·73	21·14	11·27	655·7	302·2	910·6	1796·9	866·4
Avena fatuoensis	3·42	1·75	0·41	0·02	1·40	243·5	109·5	29·3	1·7	96·0
Poa pratensis	8·12	10·36	12·43	4·50	8·11	564·5	649·4	889·4	382·5	871·5
Poa trivialis	17·04	1·82	0·81	0·01	4·68	1213·3	85·1	58·0	0·9	341·8
Dactylis glomerata	23·34	30·30	27·23	19·38	25·56	1661·8	2296·0	1948·3	1137·3	1760·5
Festuca ovina	0·66	2·05	0·30	2·55	1·39	47·0	132·2	21·5	216·7	103·4
Festuca pratensis	2·25	0·06	...	...	0·57	162·3	3·8	...	...	41·5
Lolium perenne	1·46	0·39	0·16	...	0·50	104·0	23·6	11·5	...	34·8
None yielding 1 per cent. / Absent. — Phleum pratense, Aira caryophyllea, Avena pubescens, Bromus mollis / Briza media, Cynosurus cristatus, Festuca ovina, Lolium perenne, Undetermined (chiefly Gramineæ)	1·45	0·06	0·03	0·01	0·40	103·2	3·0	2·1	0·9	27·2
	...	...	...	...	...	...	...	...	...	...
	4·30	0·94	1·60	...	1·71	312·6	58·6	114·6	...	121·5
Total	94·24	95·67	97·26	99·46	96·90	6709·9	5965·1	7102·1	8369·1	7041·6
LEGUMINOSÆ.										
Trifolium repens, T. pratense, T. minus; Lotus corniculatus, Lathyrus pratensis, Ononis arvensis.	...	...	...	...	...	...	...	...	...	...
Total	...	...	...	...	...	...	...	...	...	...
OTHER ORDERS.										
Conopodium denudatum	1·19	0·70	0·03	0·01	0·48	84·7	43·8	2·1	0·9	32·9
Rumex Acetosa	4·08	3·57	0·70	1·34	2·41	290·5	223·4	50·1	113·9	169·5
None yielding 1 per cent. — Ranunculus repens et bulbosus, Pimpinella Saxifraga, Heracleum Sphondylium, Galium verum, Achillea Millefolium, Taraxacum officinale, Lamium amplexicaule, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triquetrum	0·49	0·06	0·01	0·19	0·21	34·9	3·7	0·7	16·2	13·9
Absent. — Ranunculus acris, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Potarium Sanguisorba, Galium Aparine, Scabiosa arvensis, Centaurea nigra, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Plantago lanceolata, Veronica Chamædrys, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Scilla nutans, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	5·76	4·33	0·74	1·54	3·10	410·1	270·9	52·9	130·9	216·3
SUMMARY.										
Gramineæ	94·24	95·67	99·26	98·46	96·90	6709·9	5965·1	7102·1	8369·1	7041·6
Leguminosæ	...	...	...	...	...	...	...	...	...	...
Other Orders	5·76	4·33	0·74	1·54	3·10	410·1	270·9	52·9	130·9	216·3
Total	100·00	100·00	100·00	100·00	100·00	7120	6236	7155	8500	7257

each Species, by 800 lbs. of Ammonia-salts, and Mixed Mineral Manure, Silicates; Plot 11–2.

Increase + or decrease − compared with: −									
Plot 3, without manure.					Plot 11–1; as 11–2, but without silicates.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 4	− 1	− 4	− 6	− 4	−1	+1	+2	0	+1
− 4	− 4	− 4	− 4	− 4	−1	−1	−1	0	−1
−21	−19	−25	−26	−23	−5	+1	−1	+1	−1
−29	−24	−33	−36	−31	−7	+1	0	+1	−1
Graminem (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 59·4	− 382·3	− 74·0	− 106·6	− 130·6	+ 64·8	+ 2·1	− 44·1	+ 1·5	+ 6·3
− 30·2	+ 202·1	+1612·1	+1702·2	+ 871·6	− 92·2	−306·7	+739·9	+1035·8	+344·2
+ 902·8	+1223·9	+ 461·6	+1387·3	+ 964·2	+409·2	+475·5	−340·1	− 531·7	+ 27·5
+ 370·9	+ 34·1	+ 686·5	+1359·1	+ 613·6	−180·4	+146·3	+ 21·1	+ 277·0	+ 66·0
+ 484·8	+ 250·2	+ 908·7	+1798·7	+ 863·3	+401·0	+ 88·3	+168·4	+ 787·1	+353·7
+ 171·1	+ 47·5	− 29·1	− 23·9	+ 41·7	− 131·6	+ 84·9	+ 22·9	+ 1·0	− 8·8
+ 356·8	+ 643·7	+ 857·9	+ 880·8	+ 567·1	−305·9	− 39·9	+147·8	+ 282·6	+ 21·2
+1166·3	+ 56·1	+ 49·8	− 12·3	+ 314·9	+271·5	+ 87·6	+ 51·6	− 21·9	+ 87·8
+1606·1	+2330·0	+1853·5	+1120·7	+1750·0	− 50·5	+209·0	−852·4	− 25·7	−167·3
− 356·9	− 378·3	− 334·7	− 360·9	− 343·1	− 56·8	+101·4	− 5·6	− 69·3	− 6·5
+ 161·1	+ 3·8	− 0·2	− 0·2	+ 41·1	+ 27·2	+ 3·6	...	...	+ 7·7
− 90·4	− 110·5	− 27·5	− 107·6	− 84·0	+ 6·6	+ 19·5	+ 11·5	− 0·7	+ 9·2
− 195·9	− 99·0	− 58·7	− 63·6	− 103·8	−114·3	+ 2·4	+ 1·4	+ 0·9	− 27·3
− 62·9	+ 27·0	− 123·4	− 198·3	− 102·1	...	...	...	...	...
+ 73·3	− 145·7	+ 65·6	...	− 1·6	+119·3	+ 12·2	+ 31·6	...	+ 40·8
+4554·9	+3801·7	+5073·3	+6687·1	+5254·3	+356·8	+940·3	+ 53·8	+1741·0	+773·0
Leguminosæ (continued).									
− 247·2	− 178·3	− 147·6	− 201·9	− 193·7	− 0·7	− 0·6	− 0·7	...	− 0·5
− 247·2	− 178·3	− 147·6	− 201·9	− 193·7	− 0·7	− 0·6	− 0·7	...	− 0·5
Other Orders (continued).									
+ 58·1	− 54·5	− 44·7	− 44·1	− 22·1	− 42·5	− 54·8	− 0·8	+ 0·1	− 38·5
+ 247·8	+ 154·7	+ 21·0	+ 69·7	+ 129·8	−209·5	+ 11·1	− 27·6	− 39·0	− 66·0
− 275·3	− 377·3	− 164·2	− 184·8	− 250·1	− 87·4	0·0	0·0	+ 1·9	− 21·4
− 267·4	− 422·3	− 126·8	− 190·2	− 254·4	− 0·7	...	− 0·7	...	− 1·8
− 239·7	− 699·4	− 314·7	− 349·2	− 400·8	−344·1	− 43·7	− 29·1	− 37·0	−113·5
Summary (continued).									
+4554·9	+3801·7	+5073·3	+6687·1	+5254·3	+356·8	+940·3	+ 53·8	+1741·0	+773·0
− 247·2	− 178·3	− 147·6	− 201·9	− 193·7	− 0·7	− 0·6	− 0·7	...	− 0·5
− 239·7	− 699·4	− 314·7	− 349·2	− 400·8	−344·1	− 43·7	− 29·1	− 37·0	−113·5
+4068	+2924	+4611	+6136	+4859	+ 12	+896	+ 24	+1704	+659

There was even still more total produce, and still more nitrogen and mineral matter taken up, with the addition of the silicates; and, over the later as compared with the earlier period, the falling off in the yield of hay and its contents of mineral matter was less, and the increase in the assimilation of nitrogen was greater, than in the case of 11–1. There was, nevertheless, with an actual diminution in the amount of mineral matter, and an increase of that of nitrogen, taken up in the later years, evidence of a relative deficiency of available mineral matter compared with the available nitrogen. Under the influence of the silicates, there was an increase in the amount of the mineral constituents in the produce far beyond that of the increased quantity of silica taken up, which was extremely small in proportion to that supplied. Indeed, besides the increased amount of silica, lime, and soda, taken up, these being supplied, there was also more magnesia, potass, phosphoric acid, sulphuric acid, and chlorine, gathered; though none of these were supplied in greater amount than on 11–1. We have, therefore, with the same supplies of nitrogen, and of all the mineral constituents, except silica, lime, and soda, which were in increased amount, nevertheless a greater activity of accumulation, and greater than could be due to the direct supply of constituents by the silicates used. It is probable that the alkaline silicates reacted within the soil, serving to neutralise sulphuric acid and chlorine, and to liberate nitrogen and mineral constituents in an available condition; and also that, with the increased growth, the plants acquired increased root-range, and increased capacity of food-collection.

Referring to the table of botanical results, it will be seen that there were on the average rather fewer species on 11–2 with, than on 11–1 without the silicates, the average number found in the samples being only 18. There was also a somewhat higher average percentage of grasses in the produce; the proportion being more than 99 in the third, and nearly 97 on the average of the four separation-years. There was absolutely no leguminous plant found in any of the samples. This was so, notwithstanding that there was supplied as much potass as, and more of some other mineral constituents than, on plot 7, where the Leguminosæ were so prominent; there being there no nitrogenous manure in addition to give the Gramineæ such pre-eminent advantage in the struggle. Among Miscellaneæ only two, *Rumex Acetosa* and *Conopodium denudatum*, contributed as much as 1 per cent. to the produce in any one separation-year, and of these the *Rumex* has gone down to only about 1 per cent., and the *Conopodium* to a mere fraction in the later years; all other miscellaneous species collectively not yielding, on the average, a quarter of 1 per cent.

The chief point of interest in the detail of the botanical results is the difference of effect as compared with plot 11–1 without the silicates. There is seen to be in the later separation-years a very great increase in the relative amount of *Alopecurus pratensis*, a great increase also in that of *Avena elatior*, and some in *Poa pratensis* and *Holcus lanatus*; whilst *Agrostis vulgaris*, *Dactylis glomerata*, and most other grasses yielded, in the later years, less than on 11–1.

Thus, with the addition of silicates of lime and soda, we have more nitrogen, and

more of other mineral constituents besides those supplied, taken up, and coincidently more total growth—that is, there was more carbon assimilated, and more dry substance produced, the result of a fuller development of some of the more vigorous, freer-growing, and early maturing grasses, as *Alopecurus pratensis*, *Avena elatior*, *Poa pratensis*, and *Holcus lanatus*. All of these are, especially compared with *Agrostis*, early ripeners; and with this character it is to be supposed that they would gain in consolidation, and with this in weight, at the same time that they would tend, both by their obtrusion and more rapid accumulation of material, to limit both the space and the resources at the command of their later maturing associates. With the increased growth there was great coarseness of herbage, but a less merely tufty and patchy condition of the plot, there being many fewer bare spaces of damaged herbage. The dark green and immature condition was also somewhat less marked; whilst some species, specially *Avena elatior* in some seasons, flowered and seeded more freely; in other words, matured better. This plant, it may be noted, on both plots and in most seasons formed stem and seed more freely than any other species in the second crops; indeed, in some cases it apparently contributed more stem to the second crop on plot 11–2 than all the other species over the whole series of plots. These circumstances must not be overlooked in accounting for the considerably increased predominance of *Avena elatior*, especially on plot 11–2, where the conditions for maturation were, as has been shown, somewhat more favourable than on 11–1. On the other hand, *Dactylis* was, as a rule, by no means the most prominent in the second crops, especially in the later years, during which they have for the most part been cut and removed from the land; increasing, therefore, the exhaustion of the soil, and obviously introducing an element which should be borne in mind in judging of the causes of the changes in the flora from the third to the fourth separation-years.

It has been pointed out in reference to the results on plot 11–1 that, so far as the nitrogen and the mineral constituents supplied and taken up were concerned, there was, so to speak, potential, beyond the degree of actual, growth attained. Now, on 11–2, with somewhat greater mineral supplies, more of nitrogen and of mineral matter taken up, and some more growth, we have still, as shown both by the insufficiently matured character of the herbage, and by its chemical composition, deficient carbon-accumulation in relation to the soil-supplies—nitrogen and mineral matter—taken up. In fact, it would seem that the limits of possible growth under the influence of the soil in question, and of the average climatic conditions of the seasons, had been reached.

10. *Nitrate of soda* (550 *lbs. per acre*), *with mixed mineral manure, including potass; Plot* 14.

The same mineral manure, including potass, is annually applied to this plot as to plot 9, and the same amount of nitrogen also, but in the form of nitrate of soda instead of ammonia-salts. It has been shown that, when each of these was used without

mineral manure, a given amount of nitrogen as nitrate of soda yielded more hay, more nitrogen, and more mineral matter, and that there was a less reduction in the yield of each in the later years, than when the same amount was applied as ammonia-salts. Now, when each is applied in conjunction with mineral manure, there is again more hay produced, and more mineral matter taken up, but rather less nitrogen, with the nitrate. But, whilst there is a decrease in each item in the later years on plot 9, with the mineral manure and ammonia-salts, there is an increase of each on plot 14, with the mineral manure and nitrate of soda.

Referring to Part I. for a fuller consideration of these points, and to Part III. (to follow) for still more detailed evidence, it must suffice here to state very briefly some of the conditions of these differences of result on the two plots. The nitrogen of the nitrate distributes more rapidly both in the upper and in the lower layers of the soil than does that of the ammonia-salts. Accordingly, both free-surface-feeders and more deeply-rooting species are encouraged on the nitrate plot, and hence the collective herbage on that plot is less susceptible to the adverse influence of drought than that on plot 9. A striking instance of this occurred in 1870, and the conditions are somewhat fully described in Part I. already referred to; but it may be stated briefly that whilst in that year of very unusual drought there was a deficiency compared with the average of about 23 cwts. of hay on the mineral and ammonia plot 9, there was a deficiency of less than 1½ cwt. on the mineral and nitrate plot 14. On this plot, the deep and wiry-rooted *Bromus mollis* contributed nearly half the herbage in that year; and examinations and analyses of the soils and subsoils of the plots showed much the more extensive root-development in the lower layers on plot 14, and very much less moisture there remaining. It is obvious that the deeper-rooting species had drawn up much of their needed water from the subsoil; partly, perhaps, directly, and partly by virtue of increased capillary action induced by the pumping out of the upper layers. It was also found that, probably in part due to the action of the roots, and in part to chemical reactions, the subsoil of the nitrate plot was more disintegrated and ameliorated than that of either plot 9 or the unmanured plot 3.

With these few general remarks, indicating some of the characteristic differences of result on the two plots, we now turn to a detailed consideration of their comparative botany.

The following Table (LXXV., pp. 1364–5) gives, in the usual form, a record of the facts relating to the plot under consideration; it also shows the amounts yielded by the different orders and species compared with those on the unmanured plot 3, and on plot 9 with the mineral manure and the nitrogen supplied as ammonia-salts.

In the first place there were, on the average, two fewer Gramineæ, two fewer Leguminosæ, and 16 fewer Miscellaneæ, than without manure, the average number found in the four separations in the samples from plot 14 being 29. Compared with plot 9 there was but little difference in number; in fact, only one more species.

There is not very much difference in the average percentages of total Gramineæ,

Leguminosæ, and Miscellaneæ, on plot 9 and on plot 14. On each, there is considerable fluctuation as between the Gramineæ and the Miscellaneæ in the different separation-years; and the relations are not the same in the same season under the different conditions of the two plots. On the average, the nitrate plot gives a higher percentage of Gramineæ, and a lower percentage of Miscellaneæ; but, on the other hand, though still in insignificant proportion, it yields notably more Leguminosæ, especially of *Lathyrus pratensis*.

Bearing in mind the main features of the botany of the plots hitherto considered which received a mixture of mineral and nitrogenous manure, but the latter as ammonia-salts, it will be observed that the species predominating are very widely different. Here, with the nitrate, the most prominent plant, on the average, and with one exception in each separation-year, is *Poa trivialis*, which in no case hitherto recorded has been the first in the list. The one exception was that in 1872 *Bromus mollis* contributed more than 42 per cent., whereas in some earlier years it was estimated to have even yielded more than this, whilst *Poa trivialis* gave in that year less than 25 per cent. In the fourth separation-year, however, whilst *Poa trivialis* was only reduced to 21½ per cent., *Bromus mollis* was reduced to 8 per cent. From the first to the fourth separation-year the percentages of *Alopecurus pratensis* increased in a very striking degree, and those of *Holcus lanatus* and *Dactylis glomerata* also increased, whilst *Lolium perenne* markedly decreased. Looking to the results in the fourth separation-year, *Poa trivialis* is the first on the list, *Alopecurus pratensis* coming second, each contributing more than 20 per cent., whilst *Holcus lanatus* and *Dactylis glomerata* each contribute more than 12 per cent. Of other grasses of any prominence, *Bromus mollis* gives about 8, and *Poa pratensis* about 4 per cent.; *Avena flavescens*, *Lolium perenne*, *Agrostis vulgaris*, considerably less, and *Festuca ovina*, *Avena elatior*, and others, quite insignificant proportions.

As already intimated, the only leguminous plant which was found in more than a trace, and which increased, was *Lathyrus pratensis*; the total Leguminosæ, however, yielding on the average considerably less than 1 per cent.

Of miscellaneous species yielding in any one year as much as 1 per cent. to the produce, there are with the mineral manure and nitrate four, whilst with the mineral and ammonia there were only three. However, the fourth on the nitrate plot is the *Ranunculus* (*repens* and *bulbosus* together), which owes its place in the average column to its yield in the first separation-year only, afterwards all but disappearing. Of the remaining three, as on plot 9, *Rumex Acetosa* and *Conopodium denudatum* have each a place, but on plot 9 the third was *Achillea Millefolium*, whilst here on plot 14 it is *Anthriscus sylvestris*, which has much increased in the later years, even more than *Rumex Acetosa*.

The main features of the miscellaneous herbage may be said to be, that *Rumex Acetosa* has given the highest average proportion, but has fluctuated very much, yielding very little in the second and third, and less in the fourth, than in the first

TABLE LXXV.—Number of Species, Percentage, Quantity per Acre, &c., of each Species,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Graminea	15	14	14	15	15	...	...	...	...	...
Leguminosæ	3	3	2	1	2	...	...	...	...	...
Other Orders	10	13	14	11	12	...	...	...	...	...
Total	28	30	30	27	29	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Alopecurus pratensis	0·22	3·54	3·72	20·18	6·91	12·6	254·5	231·2	1262·9	440·3
Agrostis vulgaris	0·42	0·61	0·24	1·55	0·71	24·0	43·8	14·9	97·0	44·9
Holcus lanatus	6·60	6·63	3·67	12·75	7·41	377·4	476·5	228·1	797·9	470·0
Avena elatior	3·14	...	...	0·32	0·86	179·5	...	...	20·0	49·9
Avena flavescens	4·88	7·12	5·67	2·93	5·15	279·0	511·9	352·4	183·3	331·6
Poa pratensis	1·45	1·95	2·87	4·01	2·27	82·9	73·3	180·7	250·9	142·3
Poa trivialis	22·48	32·93	24·76	21·59	25·44	1285·4	2367·0	1538·9	1351·1	1635·5
Dactylis glomerata	10·00	7·23	3·33	12·43	8·27	571·8	823·3	207·0	781·0	520·8
Festuca ovina	0·36	1·38	0·16	0·48	0·77	20·2	113·6	10·0	30·0	51·0
Bromus mollis	18·04	17·49	42·10	9·02	21·46	1031·5	1271·6	2616·5	501·9	1355·1
Lolium perenne	13·60	9·36	5·55	2·63	7·84	789·1	672·8	344·9	164·6	492·9
None yielding 1 per cent. Absent—Anthoxanthum odoratum, Phleum pratense, Aira cæspitosa, Avena pubescens, Cynosurus cristatus, Festuca pratensis, Briza media, Festuca hillacea, Undetermined (chiefly Graminea)	2·13	1·25	0·31	0·87	1·15	121·9	89·2	19·3	54·5	71·6
	...	...	...	...	...	...	...	...	...	...
	5·48	5·21	0·79	...	2·87	313·4	374·5	49·1	...	184·2
Total	89·52	94·25	92·87	87·81	91·11	5118·8	6774·7	5771·9	5495·1	5790·1
LEGUMINOSÆ.										
Trifolium repens	0·01	0·01	...	...	0·01	0·6	0·7	...	...	0·3
Trifolium pratense	0·01	0·01	0·01	...	0·01	0·6	0·7	0·6	...	0·5
Lathyrus pratensis	0·11	0·37	1·35	0·76	0·64	6·2	26·6	83·9	47·6	41·1
Trifolium minus, Lotus corniculatus, Ononis arvensis	...	...	...	...	...	...	...	...	...	...
Total	0·13	0·39	1·36	0·76	0·66	7·4	28·0	84·5	47·6	41·9
OTHER ORDERS.										
Ranunculus repens et bulbosus	1·23	0·10	0·03	...	0·34	70·3	7·2	1·9	...	19·9
Conopodium denudatum	1·55	1·57	0·61	0·18	0·97	88·6	112·9	37·9	11·3	62·7
Anthriscus sylvestris	...	1·32	3·86	4·64	2·50	...	109·3	239·9	290·4	159·9
Rumex Acetosa	0·68	1·11	0·61	4·40	2·25	39·4	79·8	37·9	275·3	196·6
None yielding 1 per cent. Absent—Ranunculus acris, Cerastium triviale, Pimpinella Saxifraga, Heracleum Sphondylium, Centaurea nigra, Achillea Millefolium, Leontodon hispidus, Taraxacum officinale, Plantago lanceolata, Rumex crispus, Scilla nutans, Luzula campestris, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triquetrum	0·69	1·06	0·68	2·21	1·17	39·5	76·1	41·0	138·3	73·7
Absent—Ranunculus auricomus, Stellaria graminea, Potentilla reptans, Agrimonia Eupatoria, Potentilla Tormentilla, Spiræa Ulmaria, Galium verum, G. Aparine, Scabiosa arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Hieracium Pilosella, Veronica Chamædrys, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Rumex crispus, Ornithogalum umbellatum, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	10·35	5·36	5·77	11·43	8·23	501·8	385·3	358·6	715·3	512·8
SUMMARY.										
Graminea	89·52	94·25	92·87	87·81	91·11	5118·8	6774·7	5771·9	5495·1	5790·1
Leguminosæ	0·13	0·39	1·36	0·76	0·66	7·4	28·0	84·5	47·6	41·9
Other Orders	10·35	5·36	5·77	11·43	8·23	501·8	385·3	358·6	715·3	512·8
Total	100·00	100·00	100·00	100·00	100·00	5718	7188	6215	6258	6344

by 550 lbs. Nitrate of Soda and Mixed Mineral Manures, including Potass; Plot 14.

Increase + or decrease − compared with:—									
Plot 3, without manure.					Plot 9, ammonia-salts and mixed mineral manure.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 3	− 1	− 3	− 3	− 3	+3	0	−2	+2	+1
− 1	− 1	− 2	− 3	− 2	+1	+1	+1	−3	0
−18	−11	−14	−20	−16	−3	0	+1	+1	0
−22	−13	−19	−25	−20	0	+1	0	0	+1
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 134·4	+ 60·6	+ 222·7	+1355·8	+ 353·7	− 4·7	+ 250·7	+ 75·0	+1204·7	+ 381·4
− 222·7	− 243·7	− 250·4	− 216·9	− 258·5	−796·1	− 879·0	− 839·8	− 643·4	− 744·8
+ 122·6	+ 211·0	+ 189·9	+ 501·7	+ 276·2	−309·8	− 53·1	− 202·4	+ 170·1	− 121·9
+ 177·4	− 7·0	− 2·1	+ 18·3	+ 46·9	+ 172·3	+ 134·6	− 644·0	− 781·0	− 340·2
+ 206·6	+ 440·8	+ 298·0	+ 157·2	+ 277·2	−302·3	+ 308·4	+ 52·6	+ 142·8	+ 50·4
+ 74·0	+ 69·8	+ 158·2	+ 349·2	+ 137·9	−606·8	− 623·2	−1123·0	− 846·6	− 797·4
+1336·4	+2328·0	+1430·6	+1337·9	+1608·6	+ 727·1	+2251·8	+1002·6	+1344·4	+1406·4
+ 518·1	+ 465·3	+ 192·2	+ 784·4	+ 485·0	+214·6	+ 273·6	− 465·2	− 70·8	− 12·0
− 855·6	− 392·9	− 546·2	− 497·4	− 580·5	−293·2	− 877·8	− 481·1	−1280·4	− 733·0
+1027·5	+1299·9	+2616·3	+ 501·9	+1353·9	+ 746·0	+1263·7	+2130·6	+ 501·9	+1250·9
+ 594·7	+ 538·5	+ 308·9	+ 57·0	+ 374·1	+830·2	+ 618·5	+ 282·1	+ 154·9	+ 394·0
− 310·2	− 300·3	− 143·2	− 154·4	− 229·1	−702·7	− 183·1	− 138·9	− 128·3	− 297·7
− 57·7	− 22·7	− 106·2	− 172·1	− 89·4	...	...	− 0·6	...	− 0·1
+ 74·1	+ 170·0	+ 0·4	...	+ 81·1	+149·4	+ 211·4	− 82·2	...	+ 77·1
+2963·8	+4891·3	+4643·1	+3813·1	+4002·9	+852·8	+2627·3	+ 855·8	− 236·1	+ 898·8
Leguminosæ (continued).									
− 15·6	− 6·3	− 6·2	− 2·1	− 7·8	...	+ 0·2	...	...	...
− 126·1	− 69·6	− 27·0	− 49·4	− 70·5	+ 0·6	+ 0·7	+ 0·6	− 0·6	+ 0·4
− 32·2	+ 3·9	+ 67·8	− 8·4	+ 7·8	− 1·5	+ 18·5	+ 82·6	+ 44·0	+ 35·9
− 55·9	− 78·3	− 97·7	− 83·4	− 81·3	...	...	...	− 20·6	− 5·1
− 230·8	− 150·3	− 63·1	− 154·3	− 151·6	− 0·9	+ 19·4	+ 83·4	+ 22·8	+ 31·2
Other Orders (continued).									
− 73·6	− 59·3	− 46·4	− 31·6	− 66·5	+ 61·2	+ 4·5	+ 1·9	− 2·4	+ 16·4
+ 69·0	+ 14·8	+ 8·9	− 33·6	+ 7·8	− 99·3	− 390·3	− 47·5	− 34·1	− 142·3
...	+ 109·3	+ 239·9	+ 290·4	+ 159·9	...	+ 109·3	+ 239·9	+ 290·4	+ 159·9
+ 250·7	+ 21·1	+ 8·9	+ 231·1	+ 152·9	+ 47·7	− 508·4	− 222·3	+ 87·3	− 158·9
− 371·4	− 648·9	− 190·0	− 131·5	− 335·4	− 91·1	− 37·9	− 50·7	+ 128·2	− 13·3
− 17·7	− 21·3	− 12·4	− 30·6	− 22·9	− 49·9	− 19·9	− 8·5	− 21·1	− 29·9
− 58·0	− 585·0	− 9·0	+ 230·2	− 104·2	−130·3	− 840·7	− 82·2	+ 416·3	− 159·2
Summary (continued).									
+2963·8	+4891·3	+4643·1	+3813·1	+4002·9	−852·8	+2627·3	+ 855·8	− 236·1	+ 898·8
− 230·8	− 150·3	− 63·1	− 154·3	− 151·6	− 0·9	+ 19·4	+ 83·4	+ 22·8	+ 31·2
− 58·0	− 585·0	− 9·0	+ 230·2	− 104·2	−130·3	− 840·7	− 82·2	+ 416·3	− 159·2
+2675	+3156	+4571	+3894	+3748	−884	+1808	+ 857	+ 204	+ 470

separation-year; *Anthriscus sylvestris* has gradually and considerably increased; *Conopodium denudatum* has very much diminished; and the several species of *Ranunculus* have become practically absent from the samples.

Comparing the actual yield per acre on plot 14 with that without manure, the table shows that on the average, and almost in every individual instance, there was a considerable excess of every grass occurring in more than 1 per cent. excepting *Festuca ovina* and *Agrostis vulgaris*, which are the two most prominent grasses of the locality under poor conditions of the soil. Those which have yielded the greatest average increase compared with the unmanured produce are most prominently and uniformly *Poa trivialis* and *Bromus mollis*, next in order coming *Dactylis glomerata*, *Lolium perenne*, *Alopecurus pratensis*, and, less prominently, *Holcus lanatus*, *Avena flavescens*, *Poa pratensis*, and *Avena elatior*.

Of Leguminosæ there was, with the one exception of *Lathyrus* in two of the years, a large deficiency of each species on plot 14, compared with plot 3 without manure.

Of Miscellaneæ there was, on plot 14 compared with plot 3, an excess of *Rumex Acetosa*, *Anthriscus sylvestris*, and, generally, of *Conopodium denudatum;* but there was a deficiency of the species of *Ranunculus*, and a very marked deficiency of a large number which occurred in too small quantity on plot 14 to be included in the list of those ever yielding 1 per cent. to the mixed herbage.

Compared with plot 9 (with the ammonia-salts), *Poa trivialis* and *Bromus mollis* are again the chief grasses in excess, and both are very largely so. In a much less degree, *Lolium perenne* and *Alopecurus pratensis* are in excess on plot 14; whilst *Festuca ovina*, *Poa pratensis*, and *Agrostis vulgaris*, are all largely, *Avena elatior* considerably, and *Holcus lanatus*, *Dactylis glomerata*, and some others in some degree, in defect.

Small as is the actual amount of leguminous herbage on plot 14, still about half of it is in excess of that on plot 9, and the excess is due, as already intimated, to *Lathyrus pratensis*.

Of miscellaneous species, the yield per acre of *Rumex Acetosa*, and of *Conopodium denudatum*, averaged considerably less on plot 14 than on plot 9; whilst the whole of the yield of *Anthriscus sylvestris* with the nitrate was in excess of that found in the samples from plot 9.

The foregoing details show—and the table should be further examined on the point—that there was a very striking difference in the growth, and in the botanical composition of the herbage, accordingly as the nitrogen (in conjunction with minerals) was applied as ammonia-salts or as nitrate of soda. With the nitrate there was on the average a notably greater quantity of gramineous herbage produced, somewhat more leguminous, but less miscellaneous herbage. With the ammonia-salts a greater number contributed a fair proportion to the herbage, and the most prominent grasses were *Poa pratensis*, *Festuca ovina*, *Agrostis vulgaris*, *Avena elatior*, and *Holcus lanatus*. With the nitrate of soda only one of these was in any special prominence; the most prominent were, instead of *Poa pratensis*, *P. trivialis* and *Bromus mollis;* and the

others in any important amount were, *Dactylis glomerata*, *Lolium perenne*, *Holcus lanatus*, *Alopecurus pratensis*, and *Avena flavescens*; the Holcus, the only one of these which was in the list of prominence on plot 9, was, however, in less quantity than it was with the ammonia-salts.

But, apart from the evidence afforded by the record of the relative and the actual quantities in which different species occurred on the two plots, there was very great difference in the general aspect and tendency of development of the herbage in the two cases. On plot 14, with the nitrate, the growth was almost invariably very much more forward, with early and very prominent development of stem, but with comparatively little growth of leaf from the base. Another character incident to that of the coarse and luxuriant stemmy growth of a few individual species is that the turf of this plot (14) is less compact and looser than that of plot 9, and of most of the other plots. According to the season of growth, or of those preceding it, one or other of the most prominent plants attracted attention, and gave character to the plot. The produce was always ready to be cut much earlier than that on any other plot; the stems being generally ripe, and even dead at the bottom, before the herbage on most of the other plots was ready for cutting. Owing to this, and to the most prominent plants flowering and seeding early, and frequently shedding seed before cutting, their permanence was favoured. This was especially the case with *Bromus mollis*, which frequently produced seed in the first growth, and gave an abundance of seedling plants in the second. On the other hand, the fact of this plant being usually annual, or biennial only, may serve to account for the great fluctuation in its degree of prominence in the different seasons, dependent presumably on the climatal circumstances having been favourable or otherwise for its reproduction and persistence. Again, the fact of the occurrence of tubers on the roots, which has been observed in this plant on this plot, may perhaps be taken to indicate a tendency to assume a perennial duration.

In conclusion, the contrast brought to view between the occurrence and predominance of different species on two plots manured in many respects so very similarly as plots 9 and 14, the only difference being that of the condition of combination in which the nitrogen is supplied, is exceedingly remarkable. The result affords a striking illustration of the influence upon a flora, of variations of conditions of growth which would at first sight appear comparatively unimportant. There was also a difference in the character of growth, dependent in part on the diversity in the natural "habit" of the plants favoured, by virtue of which, again, it is that they have become susceptible to the influence of the conditions provided; but the result is also in part due, directly to the known characteristic action of the manure itself, in inducing great luxuriance and, in conjunction with sufficient mineral supply, great forwardness and tendency to consolidation and maturation.

11. *Nitrate of soda (275 lbs. per acre) with mixed mineral manure, including potass; Plot 16.*

This experiment, like the rest of the nitrate series (plots 14, 15, 16, and 17), did not commence until the third year (1858). Plot 16 received annually the same description and amount of mixed mineral manure, including potass, as plot 14, but in conjunction with only 275 lbs. instead of 550 lbs. of nitrate of soda, supplying, therefore, only half the quantity of nitrogen. The botanical details will show that this reduction in the supply of the element contributing characteristically to luxuriance, with at the same time the maintenance of the conditions tending rather to maturation, has very materially affected the results of the struggle among the component plants of the mixed herbage.

The first point to notice (Table LXXVI., pp. 1370–1) is that there was on the average a greater number of species found in the samples from plot 16, with the smaller than in those from plot 14, with the larger amount of nitrate. This was the case within each of the three groups; there being one more grass, two more Leguminosæ, and five more Miscellaneæ; but in the fourth separation-year there were as many as three more Leguminosæ, and 11 more Miscellaneæ, in the samples from plot 16 than in those from plot 14. Taking the average of the four separation-years, there were 37 species found, against 29 with the mineral manure and double quantity of nitrate, and 49 without manure. There was also, with a tendency to the further reduction in the number on plot 14 from one year to another, within the separation period, a greater tendency to regain in number over the same period on plot 16; the numbers found in the four separation-years being 34, 34, 36, and 41, respectively.

There was a considerably smaller average percentage of total Gramineæ with the smaller than with the larger amount of nitrate (and mineral manures). There was a much larger, and a greatly increasing, percentage of leguminous herbage, and a considerably higher average, but a gradually diminishing, proportion of total Miscellaneæ. The herbage was, in fact, less exclusively gramineous, and, upon the whole, considerably more mixed, with the smaller amount of nitrate, and the consequent less luxuriance of the freer-growing species.

Among the grasses, neither *Poa trivialis* nor *Bromus mollis*, which were so prominent on plot 14, was so in any degree on plot 16. *Poa trivialis*, however, maintained its position very much better than *Bromus mollis*, which yielded only a fraction of 1 per cent. in the fourth separation-year. Nor was any other grass so prominent on the average on plot 16 as both of these were on plot 14. On the other hand, on plot 16, the prevalent but poor grasses of the locality, *Agrostis vulgaris* and *Festuca ovina* are, upon the whole, the most prominent grasses; whilst each of these was in most insignificant amount on plot 14. In about equal prominence with *Agrostis vulgaris* and *Festuca ovina*, are *Avena flavescens*, with a tendency to diminish, *Holcus lanatus*, with fairly uniform occurrence, and *Alopecurus pratensis*, with marked tendency to

increase; the last two of these, it will be remembered, also asserted considerable prominence in the later years on plot 14; whilst *Avena flavescens* was found in comparatively small and diminishing percentage on that plot. Of other grasses that were fairly prominent on plot 14, *Dactylis glomerata* is in very much less amount, though somewhat increasing, on plot 16. *Lolium perenne* declined on both plots, but gave the highest average amount on plot 14. *Anthoxanthum odoratum* and *Avena pubescens*, neither of which reached 1 per cent. in either separation-year on plot 14, each increased and averaged about 2 per cent. on plot 16.

The difference in the prevalence of Leguminosæ on the two plots is most striking. With the forced luxuriant growth of individual grasses with the larger amount of nitrate, there was not, on the average, 1 per cent. of leguminous herbage; but, with the smaller amount of nitrate there was, on the average, more than 5 per cent., rising from little over 2 in the first, to nearly 9½ in the fourth separation-year. The table will show that practically the whole of the increase was due to enhanced development of *Lathyrus pratensis*.

Whilst on plot 14, with the larger amount of nitrate, there were only four species of the miscellaneous group yielding in any one of the four separation-years 1 per cent. to the herbage, there were, on plot 16, with the smaller amount of nitrate, seven species which attained this degree of prominence. *Rumex Acetosa* was, on the whole, the most prominent on both plots; *Conopodium denudatum* was decidedly the more generally prominent with the smaller amount of nitrate, as also was *Achillea Millefolium*, which was not in the list of the first four on plot 14. The several species of *Ranunculus* were, again, more prominent on plot 16; and *Plantago lanceolata* and *Centaurea nigra* each came into the foremost list on that plot, but not on plot 14. On the other hand, *Anthriscus sylvestris*, which became so prominent in the later years on plot 14, in neither year reached anything like 1 per cent. on plot 16.

Upon the whole, the Miscellaneæ, like the Leguminosæ, yielded a higher average proportion to the mixed herbage on plot 16; but, unlike the Leguminosæ, the quantity of the Miscellaneæ diminished from one separation-year to another. This result was chiefly due to the diminishing proportions of *Rumex Acetosa*, *Conopodium denudatum*, and *Ranunculus repens* and *R. bulbosus*. Lastly, on this point, it is evident that, among the Miscellaneæ, as among the grasses, the herbage was considerably the more mixed with the smaller amount of nitrate, and the coincident less forced luxuriance, and less active struggle.

Looking to the columns of actual yield per acre of each species, and of the increase or decrease of each, compared with plot 3 without manure, and with plot 14 with the double quantity of nitrate, the more evenly mixed character of the herbage is again clearly brought to view. Compared with the produce without manure, it is seen that there is, on the average of the four separation-years, a more or less considerable increase of nine out of the eleven specially enumerated grasses; and there was a diminution, but in only a small degree, of the remaining two, namely, *Anthoxanthum*

TABLE LXXVI.—Number of Species, Percentage, Quantity per Acre, and Mixed Mineral Manure,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	17	14	17	15	16	...	...	...	...	...
Leguminosæ	3	4	4	4	4	...	...	...	...	...
Other Orders	14	16	15	22	17	...	...	...	...	...
Total	34	34	36	41	37	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	1·42	1·78	1·40	2·22	1·70	73·5	105·7	62·7	126·3	94·3
Alopecurus pratensis	0·67	9·27	15·22	12·23	9·12	34·7	491·2	681·1	142·6	337·2
Agrostis vulgaris	12·49	13·02	12·40	14·36	13·27	646·7	690·0	554·9	820·9	734·9
Holcus lanatus	10·45	11·69	5·08	12·04	9·56	541·1	624·4	227·3	770·5	552·3
Avena pubescens	1·49	1·72	1·54	3·34	2·02	77·2	102·2	68·9	203·6	113·0
Avena flavescens	19·37	14·08	18·20	6·67	14·57	981·2	967·7	841·3	426·6	779·4
Poa trivialis	4·67	8·96	6·43	4·02	6·79	230·7	482·2	292·3	282·9	322·5
Dactylis glomerata	1·39	2·39	3·75	4·63	3·14	82·4	153·9	167·6	292·2	171·4
Festuca ovina	11·13	10·44	10·23	10·98	12·14	578·3	670·1	462·3	1015·6	686·6
Bromus mollis	2·04	2·64	2·03	0·57	1·82	109·7	156·6	90·9	34·7	97·0
Lolium perenne	5·35	6·23	3·10	3·75	4·73	302·9	370·1	138·7	229·6	260·1
None yielding 1 per cent. (Phleum pratense, Aira cæspitosa, Avena elatior, Poa pratensis, Briza media, Cynosurus cristatus, Festuca pratensis	0·65	0·39	0·90	0·83	0·76	33·6	30·1	40·2	50·7	40·0
Absent—Festuca bulbosa	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	4·99	1·04	0·80	...	1·63	259·3	61·8	22·4	...	85·6
Total	72·01	84·43	81·38	82·94	81·74	4539·2	5015·2	3630·7	5056·0	4440·3
LEGUMINOSÆ.										
Trifolium repens	0·35	0·30	0·32	0·01	0·29	19·1	29·7	14·3	0·6	15·7
Trifolium pratense	1·85	0·70	0·43	0·11	0·77	95·5	41·6	19·3	6·7	40·9
Lotus corniculatus	...	0·02	0·02	0·06	0·03	...	1·2	0·9	3·7	1·4
Lathyrus pratensis	0·04	0·37	0·68	3·23	4·13	2·1	33·6	290·9	562·0	224·2
Total	2·24	1·79	7·45	3·40	5·22	116·6	106·3	333·4	573·0	282·2
OTHER ORDERS.										
Ranunculus acris	0·28	0·05	0·79	1·24	0·76	42·3	9·0	35·4	75·6	40·8
Ranunculus repens et bulbosus	4·06	0·33	0·33	0·26	1·20	241·6	19·6	14·8	15·6	72·5
Compositæ dandelium	4·50	4·30	2·90	0·51	2·42	233·0	265·1	174·5	31·1	180·9
Centaurea nigra	...	0·76	1·14	0·31	0·55	...	4·9	51·0	18·9	18·7
Achillea Millefolium	2·47	1·76	2·29	1·50	2·26	127·9	104·5	147·2	94·5	118·5
Plantago lanceolata	1·25	0·84	0·97	0·22	0·82	64·7	49·9	31	13·4	32·7
Rumex Acetosa	5·46	3·62	1·19	2·19	3·61	282·7	333·6	53·3	133·5	200·8
None yielding 1 per cent. (Ranunculus auricomus, Sedum acre, Geranium pratense, Leontodon hispidus, Tragopogon pratensis, Veronica Chamædrys, Ajuga reptans, Primula veris, Lamium amplexicaule, Hypnum squarrosum, H. rutabulum, H. triquetrum, Galium Aparine, Scabiosa arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Rumex crispus, Sclleria nutans, Carex pracox, Ophioglossum vulgatum	1·46	0·20	0·26	1·38	0·84	23·6	17·2	11·6	84·2	34·5
Absent—Agrimonia Eupatoria, Poterium Sanguisorba, Galium verum, Campanula rotundifolia, Erodium cicutarium, Hieracium sylvaticum, Hypericum perforatum, Origanum vulgare, Pimpinella Saxifraga, Rhinanthus Crista-galli, Salvia pratensis, Scabiosa Succisa, Silene inflata, Trifolium arvense, Vicia Cracca	...	...	...	...	...	...	...	...	...	...
Total	19·75	13·78	10·97	7·66	13·04	1022·7	813·5	490·9	467·0	699·8
SUMMARY.										
Gramineæ	72·01	84·43	81·38	82·94	81·74	4539·2	5015·2	3630·7	5056·0	4440·3
Leguminosæ	2·24	1·79	7·45	3·40	5·22	116·6	106·3	333·4	573·0	282·2
Other orders	19·75	13·78	10·97	7·66	13·04	1022·7	813·5	490·9	467·0	699·8
Total	100·00	100·00	100·00	100·00	100·00	5178	5940	4475	6096	5422

Acre, &c., of each Species, by 275 lbs. Nitrate of Soda, with including Potass; Plot 16.

Increase + or decrease − compared with :—									
Plot 3, without manure.					Plot 14; as 16, but with double quantity of nitrate.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 1	−1	0	− 2	− 1	+2	0	+3	0	+1
− 1	0	0	0	0	0	+1	+2	+ 3	+2
−14	−8	−13	− 9	−11	+4	+3	+1	+11	+5
−16	−9	−13	−11	−13	+6	+4	+6	+14	+8
Grasses (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 67·1	− 197·8	− 22·8	+ 14·3	− 69·1	+ 53·5	+ 90·4	+ 61·4	+ 131·5	+ 83·7
− 102·3	+ 297·3	+ 672·6	+ 736·5	+ 401·8	+ 12·1	+ 236·7	+ 448·9	− 317·3	+ 47·9
+ 300·0	+ 821·5	+ 399·8	+ 574·9	+ 421·5	+ 92·7	+ 765·2	+ 840·0	+ 791·8	+ 686·0
+ 367·3	+ 439·9	+ 168·1	+ 473·9	+ 364·5	+ 143·7	+ 217·9	− 0·8	− 27·4	+ 88·3
− 217·3	− 0·1	+ 10·5	+ 140·0	− 16·7	+ 23·7	+ 36·1	+ 97·1	+ 174·6	+ 72·6
+ 679·8	+ 920·7	+ 763·9	+ 861·1	+ 716·1	+ 672·3	+ 370·9	+ 488·9	+ 222·3	+ 439·8
+ 353·7	+ 493·2	+ 294·0	+ 290·6	+ 341·9	− 929·7	−1834·8	−1240·6	−1051·3	−1327·0
+ 29·7	+ 89·9	+ 153·0	+ 263·6	+ 135·6	− 489·4	− 365·8	− 32·2	− 466·6	− 340·4
+ 170·4	+ 113·6	+ 106·1	+ 490·1	+ 222·1	+ 520·0	+ 506·5	+ 482·3	+ 365·6	+ 417·6
+ 101·7	+ 185·1	+ 95·7	+ 34·7	+ 89·5	− 923·8	−1114·8	−2323·6	− 467·2	−1206·1
+ 168·5	+ 238·9	+ 99·7	+ 121·0	+ 141·3	− 456·2	− 302·7	− 206·2	+ 84·0	− 232·3
− 42·1	− 4·6	− 97·2	− 147·8	− 70·3	− 279·2	− 54·6	− 125·7	− 241·5	− 175·5
...	...	...	− 0·7	− 0·2	...	...	...	...	...
+ 19·0	− 142·7	− 20·3	...	− 37·5	+ 55·1	− 313·7	+ 26·7	...	− 98·6
+1894·3	+2881·8	+2221·9	+3374·0	+2653·0	−1079·5	−1759·5	−2121·2	− 439·1	−1349·8
Leguminosæ (continued).									
+ 1·9	+ 22·7	+ 9·1	− 2·5	+ 7·6	+ 17·5	+ 29·0	+ 14·3	+ 0·6	+ 15·4
− 40·3	− 29·7	− 9·3	− 42·7	− 30·1	+ 26·2	+ 40·9	+ 18·7	+ 9·7	+ 40·4
− 58·3	− 77·1	− 24·8	− 89·7	− 72·9	...	+ 1·3	+ 0·9	+ 4·7	+ 1·4
− 36·3	+ 11·1	+ 282·6	+ 506·0	+ 190·9	− 4·1	+ 7·2	+ 218·0	+ 514·4	+ 183·1
− 131·2	− 72·0	+ 186·8	+ 371·1	+ 89·5	+ 108·6	+ 78·3	+ 248·9	+ 328·4	+ 240·3
Other Orders (continued).									
+ 48·9	+ 2·7	+ 34·2	+ 78·9	+ 40·3	+ 49·2	− 16·6	+ 22·0	+ 21·2	+ 21·3
+ 32·7	− 47·4	− 23·5	− 65·8	− 13·5	+ 171·3	+ 12·4	+ 12·9	+ 15·6	+ 5·0
+ 259·4	+ 186·8	+ 127·7	− 13·8	+ 126·0	+ 144·4	+ 172·2	+ 136·6	+ 19·9	+ 118·2
− 9·5	− 14·9	− 16·4	− 4·2	− 9·5	...	− 4·1	+ 51·0	+ 19·9	+ 19·5
+ 81·2	+ 69·8	+ 117·9	+ 47·5	+ 78·1	+ 114·2	+ 70·7	+ 134·1	+ 53·6	+ 93·2
− 159·3	− 207·6	− 40·6	− 61·3	− 142·3	+ 54·4	+ 49·2	+ 2·5	+ 13·4	+ 29·6
+ 240·0	+ 276·1	+ 24·2	+ 89·3	+ 157·1	− 110·7	+ 204·0	+ 15·4	− 141·6	+ 4·2
− 117·2	− 269·7	− 99·8	− 37·1	− 130·7	+ 9·1	− 110·9	− 242·6	− 230·6	− 148·8
− 7·3	− 43·6	− 22·2	− 41·8	− 28·9	...	...	− 0·6	− 9·8	− 2·3
+ 372·9	− 151·8	+ 122·3	− 13·1	+ 82·9	+ 430·9	+ 433·2	+ 132·3	− 248·3	+ 187·0
Summary (continued).									
+1894·3	+2881·8	+2221·9	+3374·0	+2653·0	−1079·5	−1759·5	−2121·2	− 439·1	−1349·8
− 131·2	− 72·0	+ 186·8	+ 371·1	+ 89·5	+ 108·6	+ 78·3	+ 248·9	+ 328·4	+ 240·3
+ 372·9	− 151·8	+ 122·3	− 13·1	+ 82·9	+ 430·9	+ 433·2	+ 132·3	− 248·3	+ 187·0
+2136	+2608	+2531	+3732	+2824	− 540	−1248	−1740	− 162	− 922

odoratum and *Avena pubescens*. *Avena flavescens*, on the other hand, gave the highest average increase, and considerably higher than any other species on plot 16. Those next in order, and yielding considerably increased amounts, are *Alopecurus pratensis*, *Agrostis vulgaris*, *Holcus lanatus*, and *Poa trivialis*; whilst the meagrely-growing and poor grass *Festuca ovina*, the luxuriant *Dactylis glomerata*, as well as *Lolium perenne*, and *Bromus mollis*, yield increase in a much less degree.

Among the Leguminosæ, *Lathyrus* alone gives considerably, but *Trifolium repens* slightly, more on plot 16 than without manure; but *Trifolium pratense*, and *Lotus corniculatus*, give notably less with the manure than without any.

The increase of miscellaneous produce over the yield without manure is chiefly in *Rumex Acetosa* and *Conopodium denudatum*, in a less degree in *Achillea Millefolium* and *Ranunculus acris*; whilst there is, with the manure, considerably less of *Plantago lanceolata*, and somewhat less of *Ranunculus repens*, *R. bulbosus*, and *Centaurea nigra*. There is also, under the influence of the manure, an average deficiency of other miscellaneous species taken collectively.

The comparison which presents the greatest interest is, however, that between the actual yield of the different species and groups on plot 16 with the smaller, and on plot 14 with the larger amount of nitrate. With the smaller amount, there is a very considerable deficiency in the actual yield per acre of the grasses collectively. The greatest deficiency, and it is here very large, is in *Poa trivialis* and *Bromus mollis*. There is also a considerable deficiency of *Dactylis glomerata*, and of *Lolium perenne*. There is, on the other hand, with the smaller quantity of nitrate, a marked excess in the actual yield of *Agrostis vulgaris*, *Festuca ovina*, and *Avena flavescens*, and a less average excess of *Anthoxanthum odoratum*, *Avena pubescens*, *Alopecurus pratensis*, and *Holcus lanatus*, the last two giving a relative deficiency in the last separation-year.

Of Leguminous species there is, in proportion to the small total amount, a much greater yield with the smaller amount of nitrate. This increase is contributed by each of the four species enumerated, but in by far the greatest actual quantity by *Lathyrus pratensis*; whilst practically the whole of the much less actual yield of *Trifolium pratense*, *Trifolium repens*, and *Lotus corniculatus*, is in excess of the amount of them on plot 14.

Among the Miscellaneæ, again, the average actual increase over the quantity on plot 14 is contributed in a greater or less degree by each of the seven specially enumerated species; *Conopodium denudatum* yielding the largest amount of it, *Achillea Millefolium* and the various species of *Ranunculus* less, and *Plantago lanceolata*, *Centaurea nigra*, and *Rumex Acetosa*, less still. Of the large number collectively which do not come into the special list, the aggregate quantity yielded is, on the other hand, smaller on plot 16 than on plot 14.

So much for the detailed results obtained in the four years of complete separation. It should, however, be observed that the partial separations of subsequent years show a tendency to an increase in the proportion of total Graminеæ, to a decline in that of

Leguminosæ, and to an increase in that of the Miscellaneæ, on plot 16. How far this is merely a matter of season, or has to be taken as indicating permanent change, remains to be proved as time goes on.

The general result brought out by the botanical details is that, with the mineral manure and the smaller amount of nitrate of soda, that is with the less forcing conditions, no one species of grass is in any such prominence as are some on plot 14; a considerably greater number contributing somewhat largely, and a greater number fairly, to the produce. Moreover, those which were the most, and very characteristically, prominent on plot 14—*Poa trivialis* and *Bromus mollis*—are in insignificant amount on plot 16. Again, the two prevailing grasses of the locality, under usual conditions, *Agrostis vulgaris* and *Festuca ovina*, were all but banished with the larger, but were among the most prominent with the smaller, amount of nitrate; and a number of others which were in comparatively insignificant quantity on plot 14 characterised the herbage of plot 16. Thus, those which were the more prominent on plot 14 were of more rapid and freer growth than those which were so on plot 16; whilst, on the latter, a number of species of relatively meagre luxuriance maintained a fair position, yielding, upon the whole, with the less active struggle, a much more mixed gramineous herbage. Similar remarks, *mutatis mutandis*, apply also in some degree to the Leguminosæ, but to the Miscellaneæ in a greater degree than to them.

We have throughout spoken of the manurial conditions provided on plot 14 as being, compared with those on plot 16, such as to greatly increase luxuriance relatively to maturing tendency of growth. Yet, as a matter of fact, the herbage on plot 14 was always much more forward and riper than that on 16. This result, apparently so anomalous, is in reality by no means so. The excessive amount of nitrate forced into great prominence a few very free-growing grasses, and these were characterised by early maturity; whilst the smaller quantity of nitrate favoured a number of grasses of much more sluggish development, and later growth. It thus necessarily happened that, with the conditions of greater luxuriance, we had at the same time, owing to the very characteristically different flora encouraged, greater maturation also than with the conditions of less luxuriant growth, and, relatively to these, a greater supply of the constituents known to promote maturation.

As referred to in Part I., and as will be fully illustrated in Part III., the difference in the chemical composition of the produce of the two plots was quite consistent with the difference in the relative predominance of families and species, and with the relative condition of maturity described. Thus, *cæteris paribus*, the more mature a plant, the less will be the percentage of both mineral constituents and nitrogen in its dry substance. Again, speaking generally, the percentage of the mineral constituents is higher in the Leguminosæ than in the Gramineæ, and higher still in the Miscellaneæ, of the mixed herbage; and the percentage of nitrogen is somewhat higher in the Miscellaneæ, and considerably higher in the Leguminosæ, than in the Gramineæ. Quite consistently with these facts, the percentage, both of mineral constituents and

of nitrogen, was lower in the dry substance of the more gramineous and the riper produce of plot 14, than in the more mixed and less matured herbage of plot 16.

Another point of interest brought out by a consideration of the mutual relations of the botanical and the chemical results is, that whilst with the heavier, the more simple, and the more gramineous herbage of plot 14, there was a greater actual quantity of both nitrogen and of mineral constituents taken up over a given area, the excess is comparatively small. In fact, with about 41 lbs. more nitrogen applied per acre per annum to plot 14 than to plot 16, the latter took up within about 7 lbs. per acre per annum as much as the former, and very nearly as much of several of the more important mineral constituents. The probable explanation of the obviously more complete utilization, either of the nitrogen supplied, or of the stores of it within the soil itself, is that, with the much greater variety of herbage, there was, at the same time, a more varied range of root-distribution, and a more varied food-collecting capacity. And, with these, there was, with actually less of the mineral constituents taken up with equal supplies provided, still very much more in proportion to the nitrogen supplied, and to the increased luxuriance induced.

12. *Ammonia-salts* (400 *lbs. per acre*), *and superphosphate of lime*; *Plot* 4–2.

In the experiments hitherto considered in which nitrogenous and mineral manures were used together, the mineral manure has been very complex, supplying more of all the mineral constituents, excepting silica, than were taken up. The effects of a given amount of nitrogenous manure with more or less partial mineral manures will now be described; and from the results a judgment can be formed as to which of the mineral constituents the characteristic effects, botanical or otherwise, are to be attributed. Among the series the experiment first to be noticed is that in which the mineral manure consisted of superphosphate of lime alone; and the results obtained with this in conjunction with ammonia-salts (plot 4–2) will be compared, not only with those without manure, but with those with the same amount of ammonia-salts used alone, that is to say, without any mineral manure whatever (plot 5). The experiment with the superphosphate of lime and ammonia-salts (plot 4–2), like that with the superphosphate alone (plot 4–1), did not commence until the fourth year (1859).

The addition of the superphosphate to the ammonia-salts increased the average amount of produce by more than one-third, the annual yield of nitrogen by about one-fifth, and that of the mineral matter taken up about in the proportion of from two to three. Not only was there very considerable increase in the amount taken up of those constituents which were supplied by the "superphosphate" (lime, some magnesia, phosphoric acid, and sulphuric acid), but there was also a considerably larger amount of both potass and silica, to say nothing of soda and chlorine, taken up, though neither of these was supplied. There is in these facts clear evidence of the defective supply of minerals on plot 5 compared with plot 4–2; but, inasmuch as the amounts of

several of the mineral constituents taken up declined in the later years in about the same proportion on plot 4–2 as on plot 5, and the quantity of potass (which was not supplied) did so even in a much greater degree, it is obvious that there was still very considerable deficiency of some of the mineral constituents required.

The following Table (LXXVII., pp. 1376–7) gives the botanical results in the same form as usual; and it further shows the amount of yield of each species on plot 4–2 compared with that on plot 5 without the "superphosphate."

There is an average of 19 fewer total species on 4–2 with the ammonia-salts and superphosphate of lime, than without manure. The average number of grasses was reduced by three, that of Leguminosæ by two, and that of Miscellaneæ by 14. There were even, on the average, one grass, one Leguminosæ, and one Miscellaneous species, less than on plot 5 with the ammonia-salts without superphosphate. The average number of species found on the plot was 30, reducing from one separation-year to another, as follows: 35, 30, 28, 26.

The produce showed a higher proportion of gramineous herbage from one separation-year to another, and higher than with the ammonia-salts alone.

Leguminosæ were scarcely represented; *Lathyrus pratensis* being the only leguminous plant which has come into the samples in each separation-year, and then in only insignificant proportion.

Of Miscellaneous species only five came into the list of those yielding more than 1 per cent. in any one year, whilst there were seven such with the ammonia-salts alone.

The results relating to the Graminеæ are very striking. As with the ammonia-salts alone, so now with ammonia-salts and superphosphate of lime, *Festuca ovina* is not only, on the average, the most prominent grass, but it has enormously increased in predominance, yielding more than 50 per cent. to the produce on both plots in the last separation-year. On both plots, again, *Agrostis vulgaris* is the second in predominance; and it also increased, but in a much less degree, than *Festuca ovina*. It increased more in percentage, but not in actual weight, on plot 5 with the ammonia-salts alone, than where they were used in conjunction with superphosphate of lime; whilst the *Festuca ovina* increased the most under the latter condition. In the later, wetter seasons, the *Agrostis* has apparently gained in relative predominance. The only other grasses which yielded even moderate average percentages to the herbage on plot 4–2 were *Holcus lanatus*, *Alopecurus pratensis*, and *Poa trivialis*, each of which however, declined very considerably in the later years; whilst *Avena pubescens*, *Lolium perenne*, and *Avena flavescens*, which were fairly represented in the first separation-year, contributed scarcely anything in the last. Besides these, *Anthoxanthum odoratum*, *Avena elatior*, *Poa pratensis*, and *Dactylis glomerata* yielded, upon the whole, small but fluctuating percentages.

In the last separation-year more than 82 per cent. of the produce on plot 5, with the ammonia-salts alone, consisted of *Festuca ovina* and *Agrostis vulgaris* together, and nearly 80 per cent. did so on plot 4–2; but, as already said, the produce on the latter

TABLE LXXVII.—Number of Species, Percentage, Quantity per Acre, &c., of

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	14	14	15	13	14	...	...	...	...	...
Leguminosæ	3	3	3	2	3	...	...	...	...	...
Other Orders	18	13	11	11	14	...	...	...	...	...
Total	35	30	29	26	30	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	2·74	0·62	1·47	2·36	2·00	106·5	240·2	47·0	110·8	126·1
Alopecurus pratensis	0·66	14·75	3·94	1·56	5·23	31·4	641·9	125·9	74·2	218·4
Agrostis vulgaris	19·38	14·00	20·69	24·39	19·39	921·7	609·3	661·9	1145·3	833·5
Holcus lanatus	16·21	10·53	2·03	0·03	8·70	771·0	458·3	64·9	2·3·1	304·3
Avena elatior	2·46	0·41	2·46	1·02	1·59	117·0	17·8	79·2	47·9	65·5
Avena pubescens	7·38	3·94	0·29	0·03	2·90	351·0	171·4	9·0	1·4	132·2
Avena flavescens	2·09	0·41	0·09	0·03	0·65	99·4	17·8	2·9	1·4	30·4
Poa pratensis	0·67	3·57	3·11	1·56	2·60	31·9	155·4	163·3	73·3	109·2
Poa trivialis	3·14	2·15	2·10	0·31	3·17	387·1	93·6	67·1	14·8	140·6
Dactylis glomerata	2·23	0·38	0·16	1·83	1·16	106·4	16·6	5·1	85·9	54·0
Festuca ovina	6·80	26·00	49·29	55·20	34·35	323·4	1135·4	1574·6	2592·2	1406·5
Lolium perenne	6·47	1·26	0·70	0·21	2·19	307·7	55·2	22·4	9·9	99·8
None yielding 1 per cent. / Absent. — Alra cæspitosa, Briza media, Festuca pratensis, F. elatior, Bromus mollis	0·79	0·21	0·07	0·08	0·30	37·6	9·1	2·2	3·8	13·1
Absent. — Phleum pratense, Cynosurus cristatus, Festuca hillacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	4·74	2·51	0·34	...	1·90	225·4	109·3	10·9	...	86·4
Total	80·31	80·13	86·85	94·63	87·43	3819·5	3748·4	2832·3	4443·8	3711·0
LEGUMINOSÆ.										
Trifolium repens	0·01	0·01	...	0·01	0·01	0·5	0·4	...	0·5	0·4
Trifolium pratense	0·01	...	0·01	...	0·01	0·5	...	0·3	...	0·2
Lathyrus pratensis	0·07	0·03	0·02	0·03	0·03	3·3	1·3	0·7	1·4	1·6
Lotus corniculatus	...	...	...	...	...	...	...	...	...	...
Total	0·09	0·04	0·03	0·04	0·05	4·3	1·7	1·0	1·9	2·2
OTHER ORDERS.										
Ranunculus repens et bulbosus	2·14	0·04	0·01	...	0·54	101·8	1·8	0·3	...	25·9
Cynosurus dactylatum	1·29	2·65	0·39	0·11	1·11	61·3	113·3	12·5	5·2	48·8
Centaurea nigra	0·01	0·21	1·25	0·85	0·58	0·5	9·1	39·9	39·9	22·4
Achillea Millefolium	1·77	1·49	1·78	0·27	1·32	84·1	64·9	55·9	12·7	54·4
Rumex Acetosa	12·39	6·42	6·95	3·09	7·96	636·6	366·4	218·9	145·0	341·7
None yielding 1 per cent. / Absent. — Ranunculus acris, Stellaria graminea, Cerastium trivials, Pimpinella Saxifraga, Heracleum Sphondylium, Galium verum, G. Aparine, Scabiosa arvensis, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Luzula campestris, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triane	1·00	1·02	1·07	1·01	1·04	47·7	44·4	34·2	47·5	43·5
Absent — Potentilla reptans, Agrimonia Eupatoria, Poterium Sanguisorba, Bellis perennis, Chrysanthemum Leucanthemum, Spiræa Ulmaria, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Scilla nutans, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	19·60	13·83	11·32	5·33	12·32	932·2	601·9	361·7	250·3	536·5
SUMMARY.										
Gramineæ	80·31	80·13	86·85	94·63	87·43	3819·5	3748·4	2832·3	4443·8	3711·0
Leguminosæ	0·09	0·04	0·03	0·04	0·05	4·3	1·7	1·0	1·9	2·2
Other Orders	19·60	13·83	11·32	5·33	12·32	932·2	601·9	361·7	250·3	536·5
Total	100·00	100·00	100·00	100·00	100·00	4756	4352	3195	4696	4250

each Species, by 400 lbs. Ammonia-salts, and Superphosphate of Lime; Plot 4-2.

Increase + or decrease − compared with:—									
Plot 3, without manure.					Plot 5, ammonia-salts alone.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 4	− 1	− 2	− 4	− 3	−3	−1	0	0	−1
− 1	− 1	− 2	− 3	− 2	−1	−1	−1	0	−1
−10	−11	−17	−20	−14	+1	−4	−2	−3	−1
−15	−13	−21	−26	−19	−3	−6	−3	−3	−3
Graminеæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 24·1	− 49·3	− 30·3	− 10·2	− 30·3	−113·9	+ 80·0	− 29·4	− 9·9	− 24·3
− 102·6	+ 448·0	+ 117·4	+ 67·1	+ 131·8	+ 6·4	+ 626·4	+100·1	+ 67·4	+ 201·4
+ 578·0	+ 821·8	+ 392·6	+ 851·4	+ 530·1	− 14·8	− 81·0	− 11·3	+ 275·6	+ 41·3
+ 517·2	+ 197·8	+ 9·7	− 13·6	+ 200·5	+3·4·5	+ 288·0	+ 17·2	+ 194·2	+ 229·3
+ 114·9	+ 10·8	+ 77·1	+ 46·7	+ 62·4	− 34·4	− 74·1	+ 41·8	+ 41·1	− 6·4
+ 46·5	+ 69·2	− 49·4	− 62·2	− 9·5	+ 69·3	+ 130·7	+ 3·0	− 2·1	+ 55·2
+ 27·0	− 44·2	− 54·5	− 94·1	− 29·9	+ 74·4	+ 2·6	− 1·7	+ 1·1	+ 19·1
+ 23·0	+ 162·7	+ 101·8	+ 71·6	+ 104·8	− 9·3	+ 146·9	+ 14·0	+ 69·5	+ 68·0
+ 340·1	+ 54·6	+ 58·9	+ 1·4	+ 113·7	+332·6	+ 83·7	+ 62·3	+ 14·3	+ 123·7
+ 84·7	− 41·4	− 9·7	+ 69·9	+ 19·2	+ 16·3	− 29·4	− 12·5	− 10·0	− 8·9
− 82·5	+ 629·9	+1219·4	+2074·7	+ 962·0	−324·1	+ 124·6	+404·1	+1018·5	+ 256·0
+ 113·3	− 75·1	− 16·6	− 97·7	− 19·0	+179·4	+ 19·2	− 1·9	+ 7·2	+ 51·0
− 25·6	− 15·3	− 103·6	− 169·7	− 78·4	+ 18·3	+ 4·5	+ 1·5	+ 3·2	+ 6·7
− 8·5	− 4·3	− 18·2	− 23·9	− 13·0	− 0·4	− 0·3	− 0·2	...	− 0·2
− 13·9	− 95·2	− 37·9	...	− 36·7	+ 92·4	+ 56·0	− 13·0	...	+ 33·9
+1664·5	+1565·0	+1703·5	+2761·8	+1923·7	+492·7	+1373·0	+703·0	+1667·1	+1058·9
Leguminosæ (continued).									
− 15·7	− 9·6	− 6·2	− 2·6	− 7·7	+ 0·1	+ 0·1	− 0·3	+ 0·5	+ 0·1
− 136·2	− 70·3	− 27·3	− 49·4	− 70·8	− 1·0	− 0·3	+ 0·3	...	− 0·2
− 35·1	− 21·4	− 15·4	− 54·6	− 31·7	+ 2·5	+ 1·0	− 0·3	− 0·1	+ 0·7
− 55·9	− 73·3	− 97·7	− 93·4	− 81·3	− 1·9	− 10·3	− 10·3	− 4·1	− 6·7
− 242·9	− 176·6	− 146·6	− 200·0	− 191·5	− 0·3	− 9·5	− 10·6	− 3·7	− 6·1
Other Orders (continued).									
− 47·1	− 65·2	− 48·0	− 81·6	− 60·5	+ 89·5	− 0·8	− 1·7	− 2·6	+ 21·1
+ 31·7	+ 17·0	− 34·3	− 39·7	− 6·3	+ 17·0	− 74·4	− 13·1	− 14·0	− 31·1
− 9·0	− 10·6	+ 0·3	+ 14·8	+ 0·2	+ 0·1	− 71·2	− 14·9	+ 24·3	− 19·4
+ 87·4	+ 39·2	+ 26·6	− 34·3	+ 14·0	+ 32·9	+ 29·9	+ 29·5	+ 8·0	+ 24·9
+ 594·1	+ 307·7	+ 189·8	+ 100·3	+ 286·0	+284·2	− 160·6	+ 39·7	+ 82·1	+ 61·3
− 320·5	− 612·3	− 115·1	− 127·9	− 293·9	− 14·1	− 39·4	− 50·9	− 14·6	− 29·9
− 4·2	− 31·2	− 30·2	− 62·0	− 32·0	...	...	...	− 2·6	− 0·7
+ 282·4	− 368·4	− 8·9	− 229·8	− 80·5	+409·6	− 317·5	− 11·4	+ 80·6	+ 40·3
Summary (continued).									
+1664·5	+1565·0	+1703·5	+2761·8	+1923·7	+492·7	+1373·0	+703·0	+1667·1	+1058·9
− 242·9	− 176·6	− 146·6	− 200·0	− 191·5	− 0·3	− 9·5	− 10·6	− 3·7	− 6·1
+ 282·4	− 368·4	− 8·9	− 229·8	− 80·5	+409·6	− 317·5	− 11·4	+ 80·6	+ 40·3
+1704	+1020	+1551	+2332	+1652	+902	+1046	+681	+1744	+1093

plot became more gramineous than that on the former, and it included a larger number of other grasses in moderate proportion than did the produce with the ammonia-salts alone. In fact, with the ammonia-salts alone, with a somewhat larger total number of gramineous species represented in the samples, only nine came into the list as yielding more than 1 per cent. in any one year, whilst on plot 4–2, with the superphosphate in addition, there were 12 that came into this category. The result was a somewhat more mixed herbage so far as the gramineous components were concerned, due, however, it is to be supposed, rather to more of maturing tendency, and therefore of consolidation, giving weight, than to increased luxuriance of the species which came the more into prominence.

Among the five Miscellaneæ coming into the foremost list, *Rumex Acetosa* was, as in other cases, by far the most prominent; next in order coming *Achillea Millefolium*, *Conopodium denudatum*, *Centaurea nigra*, and various species of *Ranunculus*. But of these, *Rumex* declined from more than 13 to only 3 per cent.; the species of *Ranunculus* almost disappeared; *Conopodium denudatum* and *Achillea Millefolium* also declined, although in the second cuttings the *Achillea* has, in the later years, shown even more prominence than the *Rumex*, owing probably to the fact that it is less injured by cutting, and more particularly to the circumstance that the *Rumex* is more advanced in development at the time of the first cutting, and is therefore more exhausted by the profusion of seed that is formed, and is less ready to produce shoots in the aftermath. The only miscellaneous species that showed any tendency to increase, though occurring in comparatively small actual quantity, was *Centaurea nigra*. Upon the whole, however, the percentage of the Miscellaneæ diminished very greatly in the later years, as that of the Gramineæ increased.

Compared with the produce without manure, the ammonia-salts and superphosphate of lime gave a very large, and greatly increasing, actual amount of *Festuca ovina* and *Agrostis vulgaris*. This mixture also gave more of each of the *Poas*, more also, but in a rapidly decreasing ratio, of *Alopecurus pratensis* and *Holcus lanatus*, and slightly more of *Avena elatior* and *Dactylis glomerata*. There was, however, an actual deficiency of *Anthoxanthum odoratum*, *Avena flavescens*, *Lolium perenne*, and of a number of others taken collectively.

Of leguminous herbage there was so small a quantity that, practically, the whole of that without manure was in excess of that with the ammonia-salts and superphosphate of lime.

Of miscellaneous herbage there was, compared with the produce without manure, a great average, though diminishing, excess of *Rumex Acetosa*, a much smaller and iminishing excess of *Achillea Millefolium*, but a considerable deficiency of the various species of *Ranunculus*, and of *Conopodium denudatum*; *Centaurea nigra* showed an excess, but only in the later years.

Compared with the actual amount of each species grown by the ammonia-salts alone, the addition of the superphosphate gives, among the grasses, a greatly increasing

excess of *Festuca ovina*, and a diminishing one of *Holcus lanatus* and *Alopecurus pratensis*. In the last separation-year only was there a considerable excess of *Agrostis*. There was also, in smaller, but in fluctuating amount, an excess of *Poa pratensis*, *P. trivialis*, *Lolium perenne*, *Avena pubescens*, and *Avena flavescens*, the excess in each case more or less declining. There was, on the other hand, generally an actual deficiency of *Anthoxanthum odoratum* and *Dactylis glomerata*.

The Leguminosæ were even in somewhat less actual amount with the "superphosphate" in addition, than with the ammonia-salts alone.

Of miscellaneous herbage, the mixture yielded more than the ammonia-salts alone, especially of *Rumex Acetosa* and *Achillea Millefolium;* whilst there was, excepting in the first year, a reduction in the amount of the species of *Ranunculus*, and also of *Conopodium; Centaurea nigra* was sometimes in deficiency, sometimes in excess.

The main effect of the addition of superphosphate to the ammonia-salts was, then, notably to increase the total gramineous, and slightly that of the total miscellaneous herbage. The chief increase was contributed by the poorer grasses—*Festuca ovina*, *Holcus lanatus*, and *Agrostis vulgaris;* a few of rather better character developing somewhat better with the mixture than with the ammonia-salts alone.

The general aspect and character of the herbage were, however, much the same on the two plots. It consisted mainly of very dark green, fine-leaved, tufted, and stunted grasses; but these characters were less marked under the influence of the "superphosphate," which aided the formation of stem, and tended somewhat more to maturity of a few of the superficially rooting species. However, in dry seasons, the herbage has seemed rather to die at the bottom than to ripen.

As referred to elsewhere, the excessively dark green colour is indicative of a high percentage of nitrogen, an abundant formation of chlorophyll, but deficient carbon-assimilation, due to a deficiency of certain mineral constituents, relatively to the amount of nitrogen taken up. In fact, there is, so far as the nitrogen available, and the chlorophyll formed, are concerned, so to speak potential, but not actual growth.

It is obvious, therefore, that the superphosphate used did not suffice for the full efficacy of the nitrogen supplied.

13. *Ammonia-salts* (400 *lbs. per acre*), *and mixed mineral manure, with and without potass; Plots* 9 *and* 10.

The results of the experiment last considered have shown that the mere addition to ammonia-salts of superphosphate of lime (supplying phosphoric acid, sulphuric acid, lime, and some magnesia) did not suffice very materially to affect either the quantity of the produce or the character of the herbage. We have now to consider the effects of the further supply of salts of potass, soda, and magnesia, and of salts of soda and magnesia, without potass. The point will be illustrated by a comparison

of the results obtained on plot 10 with those on plot 9, those on the latter having been already separately considered.

During the first six years of the experiments, plots 9 and 10 each received, annually, the same amount of ammonia-salts (400 lbs. per acre), the same amount of superphosphate of lime (as on 4–2), and the same amount of the sulphates of potass, soda, and magnesia. The only difference between the manuring of the two plots was that, during those first six years (and the seventh), plot 10 received in addition to the manures mentioned a quantity of sawdust, which was, however, without effect. After the six years, the two plots continued to receive the same manure with the one important exception that the potass-salt was now excluded from the mixture applied to plot 10, and the quantity of the soda-salt was increased.

Referring to Part I., p. 345, for a fuller account of the facts, it may be briefly stated that, during the first six years, plot 10 had received about 900 lbs. of potass per acre, which calculation showed was considerably in excess of that removed in the crops. There was, therefore (if there were no loss by drainage, and there would certainly be but little, if any), an annually accumulating residue of potass. At any rate the result was that, compared with plot 9, there was but little falling off in the amount of total produce grown during the first five or six years after the cessation of the application of potass; and practically the same amount of nitrogen was taken up as on plot 9 with the continued supply of potass. Yet the amount of potass taken up declined even in the first year of the cessation; though it continued much in excess of that taken up on plot 4–2, where none had been supplied. The evidence was that the residue of the potass previously applied was not without effect; but the effects both as to amount of produce, and the botanical and chemical characters of the herbage, diminished considerably in the later years. The following Table (LXXVIII., pp. 1382–3) gives the botanical details in the same form as usual, and, in addition, the amount of actual yield of each species on plot 10, where the application of potass was discontinued, compared with that on plot 9, where the potass was continuously applied.

There were, on the average of the four separation-years, two fewer grasses, two fewer Leguminosæ, and 18 fewer Miscellaneæ, or 22 fewer total species in the samples from plot 10 with the discontinued supply of potass, than in those from the unmanured plot 3. The average number of species was 27, with a tendency to reduction; the numbers in the four years being 31, 27, 23, 28. It may here be mentioned that the first year of separation (1862) was the first year of the exclusion of the potass from the manure. There was even, on the average, a tendency to fewer species than on plot 9.

The percentage of total Graminem in the mixed herbage was not materially different on the two plots; but it was, upon the whole, higher on plot 10 with the smaller potass supply. Leguminosæ were in quite insignificant proportion on both plots; but in less without, than with, the continued supply of potass. On both, with general

increase in the percentage of Graminæ, there was general decrease in that of the Miscellaneæ.

Referring now more to detail, it is first to be noticed that as many as 14 species of grasses yielded more than 1 per cent. to the produce in one or other separation-year, and this is the same number as came into the list on plot 9. The next point to observe is, that no one grass is in anything like the same degree of prominence as was the case on plot 5, with ammonia-salts alone, or on plot 4–2, with the ammonia-salts and superphosphate of lime. The grass which is the most prominent, and increasing, and more so on plot 10 without than on plot 9 with continued supply of potass, is, however, *Festuca ovina*, which was so excessively prominent both with the ammonia-salts alone and the ammonia-salts and superphosphate. The next plant in order, and increasing on plot 10, is *Agrostis vulgaris*, which, it will be remembered, was also the second on the plot with ammonia alone, and on that with ammonia and "superphosphate." Succeeding to these, the grass which has gained most in prominence, and which has done so very strikingly on plot 10, is *Alopecurus pratensis*, whilst it has been but very meagrely represented on plot 9. Of the three *Avenas*, *A. elatior* has increased very much, whilst *A. pubescens* and *A. flavescens*, which were in large amount at first, have almost disappeared; and the result was very similar on plot 9. Of the two *Poas*, *P. pratensis* has fluctuated very much; upon the whole it has increased, but it has in the main been less prominent than on plot 9, whilst *Poa trivialis* has become almost extinct on both plots. *Dactylis*, which increased on plot 9 with the continuous supply of potass, diminished much on plot 10. The other grasses which maintained any degree of prominence are *Holcus lanatus*, which, however, has diminished, and *Anthoxanthum odoratum*, which has considerably increased; whilst *Bromus mollis*, *Lolium perenne*, and *Festuca pratensis* (occurring in less actual amount), have markedly declined.

Thus, the herbage was very prominently gramineous; the most prominent grasses were the inferior species of the locality, *Festuca ovina* and *Agrostis vulgaris*, but a considerable number of others contributed a fair proportion. The results show, however, curiously varying aptitude to the conditions supplied, among the different species of the same genus. This is illustrated in the increase of one, and the great decline of two of the *Avenas*; in the increase of one and the great decline of the other species of *Poa*, and in the very great increase of the one and the decline of the other species of *Festuca*.

The behaviour of *Avena elatior* being so strikingly contrasted with that of *A. flavescens* and of *A. pubescens* may perhaps suggest the question whether it should really be included in this genus, or whether its separation as a distinct genus under the name *Arrhenatherum*, as still maintained by some botanists of authority, is not more consistent with what is here elicited as to the physiological endowments of the plant, as it certainly is with its structural peculiarities. It is true that the equally different behaviour of the two *Poas* cannot be explained on any similar supposition.

TABLE LXXVIII.—Number of Species, Percentage, Quantity per Acre, &c., of each Potass;

	Number of species and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Gramineæ	16	15	15	15	15	...	...	...	...	...
Leguminosæ	2	1	2	2	2	...	...	...	...	...
Other Orders	13	11	6	11	10	...	...	...	...	...
Total	31	27	23	28	27	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	1·46	5·27	2·26	5·94	3·98	90·2	267·7	141·3	266·0	194·8
Alopecurus pratensis	2·05	2·99	10·35	10·81	7·97	126·7	149·0	447·9	503·7	382·3
Agrostis vulgaris	9·37	8·61	14·17	16·29	12·11	579·1	429·1	613·3	734·9	604·1
Holcus lanatus	9·50	8·24	4·97	4·74	6·71	587·1	410·7	198·2	221·3	354·8
Avena elatior	0·08	11·71	13·22	9·35	8·84	4·9	583·8	572·1	437·5	407·0
Avena pubescens	10·64	1·44	0·44	0·24	3·24	657·8	71·7	19·0	11·7	192·5
Avena flavescens	10·06	2·00	0·77	0·18	3·25	621·1	99·7	33·3	8·2	190·9
Poa pratensis	4·06	14·61	19·42	6·48	11·24	250·9	728·1	840·1	303·2	530·6
Poa trivialis	10·18	2·78	1·21	0·47	3·66	629·1	138·5	52·4	22·0	210·7
Dactylis glomerata	12·51	5·44	2·13	4·90	6·49	772·1	271·1	138·0	229·1	354·3
Festuca ovina	4·06	14·74	19·90	20·34	16·24	252·1	734·7	856·9	1785·4	782·3
Festuca pratensis	1·49	0·25	0·09	0·14	0·49	92·1	12·5	3·9	6·9	28·6
Bromus mollis	2·53	0·69	1·74	1·55	1·63	156·4	34·4	75·3	72·6	85·4
Lolium perenne	3·02	1·94	0·37	0·17	1·40	186·6	91·7	24·7	8·3	77·3
None yielding 1 per cent.	Phleum pratense, Aira cæspitosa, Cynosurus cristatus	0·07	0·01	0·01	0·01	0·04	4·3	0·5	0·5	0·5	1·5
Absent—Briza media, Festuca hilacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Gramineæ)	4·36	1·61	1·94	...	1·98	269·5	80·2	84·1	...	108·5
Total	80·45	82·63	94·68	93·42	89·05	3220·9	4118·2	4097·9	4558·9	4514·0
LEGUMINOSÆ.										
Trifolium repens	0·01	...	0·01	...	0·01	0·8	...	0·4	...	0·3
Trifolium pratense	...	...	...	0·01	0·01	...	...	...	0·5	0·1
Lotus corniculatus	...	...	...	0·01	0·01	...	...	...	0·5	0·1
Lathyrus pratensis	0·11	0·08	0·01	...	0·03	6·8	4·0	0·4	...	2·3
Trifolium minus, Ononis arvensis	...	...	...	...	...	...	...	...	...	...
Total	0·12	0·08	0·02	0·02	0·06	7·4	4·0	0·8	1·0	3·3
OTHER ORDERS.										
Conopodium denudatum	1·77	2·49	0·06	0·06	1·09	109·4	124·1	2·6	2·9	59·7
Achillea Millefolium	0·87	1·91	0·80	0·03	0·90	53·8	95·2	34·6	1·4	46·2
Rumex Acetosa	10·26	12·61	4·22	0·99	8·30	641·5	628·5	182·6	232·5	436·2
None yielding 1 per cent.	Ranunculus acris, R. repens et bulbosus, Cerastium triviale, Potentilla reptans, Spiræa Ulmaria, Pimpinella Saxifraga, Scabiosa arvensis, Centaurea nigra, Taraxacum officinale, Plantago lanceolata, Linum catharticum, Carex præcox, Hypnum squarrosum, H. rutabulum, H. triquetrum	1·41	0·23	0·22	0·43	0·60	87·1	14·0	9·5	23·5	33·6
Absent.	Stellaria graminea, Agrimonia Eupatoria, Potentilla Anserina, Poterium Sanguisorba, Heracleum Sphondylium, Galium Aparine, Bellis perennis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Veronica Chamædrys, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Primula veris, Scilla nutans, Ornithogalum umbellatum, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	14·43	17·29	5·30	6·56	10·89	891·6	861·8	229·3	320·1	575·7
SUMMARY.										
Gramineæ	80·45	82·63	94·68	93·42	89·05	3220·9	4118·2	4097·9	4558·9	4514·0
Leguminosæ	0·12	0·08	0·02	0·02	0·06	7·4	4·0	0·8	1·0	3·3
Other Orders	14·43	17·29	5·30	6·56	10·89	891·8	861·8	229·3	320·1	575·7
Total	100·00	100·00	100·00	100·00	100·00	6180	4984	4328	4880	5093

Species, by 400 lbs. Ammonia-salts and Mixed Mineral Manure, with and without Plot 10.

Increase + or decrease − compared with :—									
Plot 3, without manure.					Plot 9; as plot 10, but with potass every year.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
Number of Species (continued).									
− 2	0	− 2	− 2	− 2	+3	+1	−1	+2	+1
− 2	− 3	− 2	− 2	− 2	0	−1	+1	−2	0
−15	−13	−22	−20	−18	0	−2	−7	+1	−2
−19	−16	−26	−24	−22	+3	−2	−7	+1	−1
Gramineæ (continued).									
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
− 40·4	− 23·8	+ 55·7	+ 164·0	+ 38·4	+ 10·8	+ 69·5	+ 12·9	+ 107·0	+ 50·3
− 10·3	− 44·9	+ 420·4	+ 796·8	+ 290·7	+109·4	+142·2	+ 29·7	+ 747·6	+322·4
+ 232·4	+ 141·6	+ 348·0	+ 481·0	+ 300·7	−241·0	−293·7	− 261·4	+ 54·5	−185·4
+ 443·3	+ 143·2	+ 130·0	− 65·4	+ 180·8	−190·1	−118·9	− 241·3	− 356·5	−226·7
+ 2·0	+ 276·6	+ 570·0	+ 466·3	+ 403·9	+ 4·9	+442·0	− 72·9	− 333·5	+ 11·9
+ 363·1	− 30·6	− 39·4	− 51·9	+ 62·8	+ 3·3	+ 5·8	− 9·7	+ 7·5	+ 2·0
+ 548·7	+ 37·7	− 24·1	− 18·6	+ 136·5	+ 39·8	−103·7	− 286·5	− 31·6	− 95·4
+ 242·0	+ 722·4	+ 847·6	+ 814·5	+ 534·2	−422·6	+ 37·4	− 423·6	− 775·3	−401·1
+ 562·1	+ 99·5	+ 44·2	+ 9·7	+ 183·8	+ 70·8	+ 23·3	+ 16·2	+ 16·2	+ 31·6
+ 719·4	+ 213·1	+ 120·2	+ 221·5	+ 813·5	+418·9	+ 21·4	− 537·2	− 612·7	−178·5
− 153·9	+ 238·2	+ 809·7	+ 767·9	+ 535·9	− 61·4	−256·7	+ 363·8	− 54·4	− 1·7
+ 30·9	+ 12·5	+ 3·7	+ 0·7	+ 28·4	+ 1·2	+ 8·7	+ 2·3	+ 0·9	+ 4·7
+ 152·4	+ 22·7	+ 75·1	+ 73·8	+ 83·9	−129·1	+ 29·5	+ 69·8	+ 73·6	+ 11·1
− 7·9	− 42·6	− 14·3	− 99·3	− 41·0	− 82·3	+ 37·4	− 36·1	− 3·4	− 21·1
− 1·5	− 3·8	− 17·9	− 23·6	− 11·7	+ 4·3	+ 0·5	− 0·1	− 0·1	+ 1·3
− 37·7	− 22·7	− 105·2	− 172·1	− 89·4	...	...	− 0·6	...	− 0·1
+ 30·2	− 124·3	+ 35·4	...	− 14·6	+105·5	− 82·9	− 17·2	...	+ 1·4
+3123·8	+1934·8	+2969·1	+2876·9	+2726·7	−390·8	− 29·2	−1118·2	−1171·3	−677·3
Leguminosæ (continued).									
− 13·6	− 7·0	− 5·3	− 3·1	− 7·3	...	− 0·5	+ 0·4	...	...
− 136·7	− 70·3	− 27·6	− 48·9	− 70·9	...	...	...	− 0·1	...
− 55·9	− 79·3	− 97·7	− 92·9	− 81·2	...	...	...	+ 0·5	+ 0·1
− 31·6	− 19·7	− 15·7	− 56·0	− 30·5	− 0·9	− 4·1	− 0·7	− 2·6	− 2·4
...	...	...	...	...	...	...	...	− 20·6	− 5·1
− 239·8	− 174·3	− 146·8	− 200·9	− 190·4	− 0·9	− 4·6	− 0·3	− 22·8	− 7·4
Other Orders (continued).									
+ 79·8	+ 25·8	− 44·2	− 42·0	+ 4·8	− 77·5	−379·1	− 82·8	− 42·5	−145·5
+ 7·1	+ 56·5	+ 5·3	− 45·6	+ 5·8	− 71·0	− 14·1	− 56·2	− 1·0	− 34·1
+ 599·8	+ 589·8	+ 153·5	+ 248·1	+ 392·5	+290·8	+ 42·3	− 77·6	+ 74·3	+ 82·7
− 424·5	− 718·0	− 219·8	− 252·5	− 403·4	+ 69·8	− 11·2	+ 3·1	+ 3·0	+ 16·2
− 19·2	+ 42·6	− 33·1	− 68·0	− 41·0	− 47·4	− 2·1	− 4·0	− 12·7	− 16·6
+ 242·0	− 108·5	− 138·3	− 160·0	− 41·3	+189·7	−364·2	− 211·5	+ 21·1	− 96·3
Summary (continued).									
+3123·8	+1934·8	+2969·1	+2876·9	+2726·7	−390·8	− 29·2	−1118·2	−1171·3	−677·3
− 239·8	− 174·3	− 146·8	− 200·9	− 190·4	− 0·9	− 4·6	− 0·3	− 22·8	− 7·4
+ 242·0	− 108·5	− 138·3	− 160·0	− 41·3	+189·7	−364·2	− 211·5	+ 21·1	− 96·3
+3128	+1652	+2684	+2516	+2496	−222	−398	−1330	−1174	−781

Before leaving this subject it may be mentioned that, both with the ammonia-salts alone, and with the ammonia-salts and superphosphate, all three of the above-enumerated *Avenas* almost disappear. Under the same conditions, again, both the *Poas* are discouraged. It is only under the influence of the further supply of more or less potass, a condition greatly favouring stem-formation and maturation, that we get the one so-called *Avena* (*elatior*), and the one *Poa* (*pratensis*), brought into prominence; the former especially being characterised by its great tendency to form stem.

The occurrence of Leguminosæ in the samples from plot 10 is quite insignificant, even more so than on plot 9 with the more potass. In both cases, owing to the associated ammonia so forcing the Gramineæ, and it being itself not directly favourable to Leguminosæ, such herbage was practically excluded, notwithstanding the greater or less potass supply.

Whilst with the ammonia-salts alone there were seven, and with the ammonia-salts and superphosphate five, Miscellaneæ which contributed 1 per cent. to the produce in one or other of the separation-years, there were only three on each of the plots 9 and 10; the one with salts of potass, soda, and magnesia, in addition every year, and the other with soda and magnesia every year, and potass for only a few of the earlier years. The three species coming into the separate list are the same, and occur in the same order of prominence, on both plots, viz.: *Rumex Acetosa*, *Conopodium denudatum*, and *Achillea Millefolium*. The *Rumex* has, upon the whole, been the more prominent, whilst the *Conopodium* and the *Achillea* have been the less so, with the smaller supply of potass. Each of the three species has, however, declined on both plots.

Compared with the produce without manure, the table shows on plot 10 a greatly increased actual yield of gramineous herbage, and a proportionally great reduction of leguminous, and a reduced amount also of miscellaneous, herbage.

Of the grasses, there was on the average of the four separations, indeed, with few exceptions in each separation-year, an increased actual yield of every species specially enumerated, excepting *Lolium perenne*. The average increase was the greatest of *Poa pratensis*, *Avena elatior*, *Festuca ovina*, *Agrostis vulgaris*, *Alopecurus pratensis*, and *Dactylis glomerata*; and of these, those which are the most gaining in ascendancy are *Festuca ovina*, *Alopecurus pratensis*, *Agrostis vulgaris*, and *Avena elatior*; whilst *Poa pratensis* has done so in a less marked degree, and *Dactylis glomerata* has declined. Among the grasses yielding less increase over plot 3, *Holcus lanatus*, *Avena pubescens*, *A. flavescens*, *Poa trivialis*, *Bromus mollis*, and *Festuca pratensis*, have considerably declined in relative predominance; whilst, though the quantity of it is small, *Anthoxanthum odoratum* shows a gradually augmenting increase.

Practically, the whole of the leguminous produce without manure was in excess of that on plot 10.

Of the Miscellaneæ, the three species specially enumerated as the most prominent, each gives, on the average, more than without manure, especially *Rumex Acetosa*, which is very greatly in excess, as it was also on plot 9. But of the large number

occurring in only small amount, the total yield was very insignificant, and very largely in defect of that without manure; thus showing, notwithstanding the excess of *Rumex Acetosa*, a diminution in the total yield of Miscellaneæ as compared with that without manure.

It is, however, the comparison of the yield on plot 10 with the partial, with that on plot 9 with the continuous, supply of potass, which illustrates the most clearly the effects of the special conditions provided; and it brings strikingly to view the effects of potass on the mixed herbage.

The right hand division of the table shows that, with the reduced supply of potass, there was a great and increasing deficiency in total gramineous herbage, and a slight deficiency of both leguminous and miscellaneous herbage. Turning to the individual species it is seen that there was considerable reduction in the yield of *Poa pratensis*, *Dactylis glomerata*, *Holcus lanatus*, and *Agrostis vulgaris*, all more or less free-growing plants, and mostly free stem-producers; and all, excepting the *Agrostis*, show upon the whole a considerably increasing deficiency from one separation-year to another. The only grass which has shown a considerable excess compared with plot 9, and the excess of which has greatly increased in the later years, is *Alopecurus pratensis*. *Anthoxanthum odoratam* has shown a small but gradually increasing excess, whilst the stemmy *Avena elatior* especially, but *A. flavescens* in some degree, and *Festuca ovina*, have shown a deficiency. A number of other grasses have, fluctuating with the seasons, sometimes given excess and sometimes deficiency.

Lastly, it is worthy of note that whilst *Avena elatior* and *Avena flavescens* each show a deficiency, *Avena pubescens* does not; and whilst *Poa pratensis* has become the most largely deficient of the grasses on plot 10, *Poa trivialis* has, on the contrary, each year given a slight excess.

On both plots the yield of Leguminosæ was so small as to render detailed comparison superfluous.

Of Miscellaneæ, *Rumex Acetosa* yielded, on the average, more on the plot with the smaller supply of potass and the larger supply of soda; whilst, in each separation-year, both *Conopodium denudatum* and *Achillea Millefolium* were in less amount with the smaller supply of potass.

Upon the whole, then, the exclusion of the potass from the manure of plot 10 has much reduced the total growth. The reduction is more or less in each group, but by far the greatest among the grasses; and among these the tendency to decline in yield is chiefly among some of the freer-growing, and more especially stem-producing species. The most marked exception to this is that, with the decline of almost all competing species, *Alopecurus pratensis* largely increased, both in actual and in relative yield.

Apart from the differences which are brought to light in the records of percentage and actual yield of the different species, there were even more striking distinctions observable in the colour of the herbage, and in the characters of development of the

plants. These characters were found to be quite consistent with some main differences in the chemical composition of the produce.

Thus, on plot 10, where the supply of potass was discontinued, the tendency to form stem has gradually, and at length very greatly, diminished; the herbage has come to consist in a much larger proportion of leaf; it maintains a darker green colour, does not eventually ripen as on plot 9, and is altogether more patchy and uneven. The chemical examination of the produce shows that, with these characters, substantially the same amount of nitrogen continues to be taken up, on plot 10 with the discontinued supply of potass and the diminished and deficiently matured produce, as on plot 9. On the other hand, the amount of potass taken up has, in the later years, been only about one-third as much on plot 10 as on plot 9. We have here again, then, so far as the nitrogen taken up is concerned, and also the abundance of chlorophyll formed, as indicated by the colour of the herbage, in a sense, potential growth. But, with the deficient supply of potass, there is deficient stem-formation and immaturity; in fact, deficient produce; in other words, deficient carbon-assimilation. Nor did the increased supply of soda compensate for the deficiency of potass, so far as these characters of growth are concerned.

From the various facts adduced, it is evident that it was the want of a liberal available supply of potass that restricted the growth on plot 4–2, with the ammonia-salts and superphosphate of lime, and on plot 10 with the ammonia-salts, superphosphate of lime, and a liberal supply of soda and magnesia, but only a partial one of potass; indeed, the agricultural, the botanical, and so far the chemical results, concur in showing how essential is a liberal provision of potass for the full effect of the nitrogen which was at the same time supplied. The comparison of the results obtained on plots 7 and 8, the one with the mixed mineral manure each year, including potass, and the other with the potass discontinued after the first few years (as on plot 10), but in both these cases without ammonia or other artificial nitrogenous supply, showed that, under those conditions also, the potass was the most essential to the growth among the mineral constituents supplied. But, whilst when the potass was used in conjunction with ammonia, its effect was greatly to develop the Gramineæ, and practically to exclude the Leguminosæ, it was, when used without ammonia, very characteristically to increase the Leguminosæ, and very much less the Gramineæ than when the ammonia was also applied.

14. *Ammonia-salts alone* (400 *lbs. per acre*), 13 *years* (1856–1868); *succeeded by mixed mineral manure, including potass, each year since, Plot* 6.

From the commencement of the experiments, plots 5 and 6 each received the same amounts of ammonia-salts without any mineral manure, and the plots were, therefore, so far, duplicates. The only difference was, that during each of the first seven years plot 6 received sawdust in addition, which, however, had little or no effect.

On both plots, the produce much diminished, the herbage greatly deteriorated, and calculation showed that not so much nitrogen was annually taken up in the total produce as was supplied in the manure, and the increased amount of nitrogen yielded over that in the unmanured produce was not more than one-fourth as much as was supplied. It is obvious, therefore, that a large proportion of the supplied nitrogen had been without effect.

After 13 years, it was decided to stop the application of ammonia-salts on plot 6, and to apply the mixed mineral manure, including potass, instead. The application of ammonia-salts alone was, however, continued on plot 5. It seemed of interest to determine what would be the effects of the change—on the amount of produce, on the distribution of species, on the character of development of the herbage, and on its chemical composition; also to ascertain whether, or in what degree, the hitherto unrecovered supplied nitrogen would be reclaimed in subsequent years, under the influence of the mineral manures.

Let us see by reference to the table which follows (LXXIX., pp. 1388–9), what have been the effects of the change in the manuring on the botany of the plot. Besides the usual particulars, the produce on plot 6, with the ammonia-salts succeeded by mixed mineral manure, is compared with that on plot 5, with the exclusive and continuous supply of ammonia-salts, and also with that on plot 7, with the exclusive and continued supply of the mixed mineral manure.

Inasmuch as plot 6 received the same amount of ammonia-salts as plot 5 for 13 years, from 1856–1868 inclusive, the first two botanical separations (of 1862 and 1867) show the character of the herbage under the influence of that manure; and it is only the separations of 1872 and 1877 that show the character and the degree of the change in the herbage induced by the substitution of mineral manure for ammonia-salts.

Compared with the produce without manure, that on plot 6 showed an average of 13 fewer total species; but the deficiency was less in the years after than before the change, the numbers being in the four separation-years, 34, 32, 39 and 38. Compared with plot 5, with the continuous supply of ammonia-salts, plot 6 gave four fewer total species in the first two years; but in the third it gave eight more, and in the fourth nine more—that is under the influence of the mineral manure. Lastly, compared with plot 7, where the mineral manure was applied continuously from the commencement, there were fewer species on plot 6, but a much less deficiency in number after than before the change of manure.

According to the results of the four complete separations, the percentage of the total Graminea in the total produce does not seem to have varied much as a direct result of the manures, though it has done so considerably as an effect of season. The partial separations of intermediate and succeeding years do, nevertheless, show a tendency to increase in the proportion of the grasses.

Since the change, however, the Leguminosæ have increased in percentage in a striking degree, whilst the Miscellaneæ have diminished.

TABLE LXXIX.—Number of Species, Percentage, Quantity per Acre, &c., of Mineral Manure alone,

	Number of species, and proportion per cent.					Quantity per acre.				
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.										
Graminem	15	14	17	14	15	...	...	...	...	...
Leguminosæ	4	3	4	4	4	...	...	...	...	...
Other Orders	15	15	18	20	17	...	...	...	...	...
Total	34	32	39	38	36	...	...	...	...	...
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	3·92	4·31	9·22	4·69	4·83	174·5	137·6	179·5	206·5	173·5
Alopecurus pratensis	1·70	0·02	0·03	0·00	0·46	75·7	0·6	0·8	3·9	20·2
Agrostis vulgaris	21·43	14·41	23·37	9·56	16·95	954·1	460·0	650·5	362·2	606·9
Holcus lanatus	9·77	3·07	5·31	14·99	7·93	389·8	98·0	148·3	623·7	310·1
Avena elatior	3·44	0·00	3·60	2·77	4·06	153·1	207·3	101·6	116·9	144·8
Avena pubescens	14·54	0·90	1·83	1·67	4·73	647·3	29·7	51·6	70·5	199·3
Avena flavescens	1·19	0·24	1·49	0·48	0·85	52·9	7·6	42·0	20·3	30·6
Poa pratensis	2·28	1·63	2·42	1·73	2·02	101·5	52·7	68·3	73·0	73·9
Poa trivialis	1·53	0·40	0·98	0·63	0·86	68·1	12·8	27·7	26·6	33·3
Dactylis glomerata	2·05	1·71	1·28	4·09	2·28	91·3	54·6	36·1	172·7	88·7
Festuca ovina	19·23	29·93	31·15	39·02	27·10	856·4	827·7	879·0	1646·2	976·3
Lolium perenne	4·28	1·39	0·69	1·97	2·16	203·9	44·4	19·5	83·2	87·7
None yielding 1 per cent. Aira cæspitosa, Briza media, Cynosurus cristatus, Festuca pratensis, Bromus mollis	0·80	0·04	0·08	0·15	0·22	38·7	1·2	1·5	6·3	9·0
Absent—Phleum pratense, Festuca loliacea	...	...	...	...	...	...	...	...	...	...
Undetermined (chiefly Graminem)	1·77	2·00	0·81	...	1·17	79·8	66·7	22·9	...	42·1
Total	80·32	62·06	79·23	79·96	75·89	3564·7	2000·1	2235·8	3375·9	2799·1
LEGUMINOSÆ.										
Trifolium repens	0·01	0·01	0·01	0·01	0·01	0·5	0·3	0·3	0·4	0·4
Trifolium pratense	0·03	0·01	0·04	0·01	0·04	1·3	0·3	1·1	0·4	1·3
Lotus corniculatus	0·01	0·08	0·06	0·03	0·05	0·5	2·6	1·7	1·3	1·5
Lathyrus pratensis	0·23	...	1·47	0·36	2·06	10·2	...	41·5	27·70	82·2
Total	0·28	0·10	1·58	0·41	2·16	12·5	3·2	44·6	282·1	85·6
OTHER ORDERS.										
Conopodium denudatum	0·55	7·87	2·47	0·88	2·94	24·5	251·2	69·7	37·2	96·6
Centaurea nigra	...	1·40	1·41	0·44	0·81	...	44·7	39·8	18·6	26·8
Achillea Millefolium	3·34	1·08	0·99	1·73	2·56	148·7	34·9	112·4	73·6	92·9
Rumex Acetosa	12·11	24·27	7·31	7·66	12·88	539·1	774·7	211·9	323·4	462·3
Lapsana communis	0·97	0·72	1·81	1·84	1·26	43·2	23·0	51·0	45·0	45·5
None yielding 1 per cent. Ranunculus acris, R. repens et bulbosus, Stellaria graminea, Cerastium triviale, Potentilla reptans, Pimpinella Saxifraga, Heracleum Sphondylium, Galium verum, G. Aparine, Scabiosa arvensis, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Carex pracox, Hypnum squarrosum, H. rutabulum, H. triquetrum	2·23	1·90	1·90	1·12	1·80	99·3	60·6	53·6	47·2	65·2
Absent Agrimonia Eupatoria, Poterium Sanguisorba, Spiræa Ulmaria, Bellis perennis, Cardaus arvensis, Chrysanthemum Leucanthemum, Tragopogon pratensis, Leontodon hispidus, Hieracium Pilosella, Prunella vulgaris, Thymus Serpyllum, Ajuga reptans, Pinnula vera, Scilla autumnalis, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...
Total	19·20	37·24	19·19	13·36	22·25	854·9	1189·7	541·6	844·9	787·3
SUMMARY.										
Graminem	80·32	62·06	79·23	79·96	75·89	3564·7	2000·1	2235·8	3375·9	2799·1
Leguminosæ	0·28	0·10	1·58	0·41	2·16	12·5	3·2	44·6	282·1	85·6
Other Orders	19·20	37·24	19·19	13·36	22·25	854·9	1189·7	541·6	844·0	787·3
Total	100·00	100·00	100·00	100·00	100·00	4432	3192	2822	4223	3672

each Species, by Ammonia-salts alone, 13 years (1856–1868), succeeded by Mixed each year since; Plot 6.

Increase + or decrease − compared with:—

Plot 3, without manure.					Plot 5, ammonia-salts alone, every year.					Plot 7, mixed mineral manure, every year.				
1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.

Number of Species (continued).

− 3	− 1	0	− 3	− 2	−2	−1	+1	+1	0	− 3	− 2	0	−3	−2
0	− 1	0	0	0	0	−1	+1	+2	+1	0	− 1	0	0	0
−13	− 9	−10	−11	−11	−3	−2	+5	+6	+2	− 7	− 7	−2	−3	−3
−16	−11	−10	−14	−13	−4	−4	+8	+9	+3	−10	−10	−2	−6	−7

Gramineæ (continued).

lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
+ 43·9	−150·9	+ 90·6	+ 86·5	+ 17·1	− 47·9	− 44·6	+ 29·1	+ 82·8	+ 22·1	+ 29·1	− 37·6	+ 69·3	+ 44·3	+ 26·6
− 61·3	−193·3	− 7·7	− 3·3	− 66·4	+ 30·7	− 14·9	− 20·0	− 3·0	+ 3·2	+ 60·7	− 32·6	− 48·9	− 20·7	− 11·9
+ 607·4	+172·5	+ 394·2	+ 48·3	+ 305·5	+ 17·9	−233·3	− 9·7	− 507·6	−183·3	+ 638·2	+ 206·3	+ 163·1	−250·6	+189·1
+ 210·0	−167·5	+ 90·6	+ 332·0	+ 116·2	− 24·7	− 72·3	+102·1	+ 532·5	+126·2	+ 139·2	− 42·5	+ 16·0	− 42·5	− 79·7
+ 151·0	+200·5	+ 99·5	+ 116·7	+ 141·7	+ 1·7	+115·6	+ 64·2	+ 110·1	+ 72·9	+ 48·5	+ 204·9	+ 82·1	+ 51·1	+ 96·2
+ 362·9	− 79·6	− 9·3	+ 6·9	+ 69·8	+362·6	+ 7·9	+ 46·8	+ 67·0	+121·5	+ 30·3	− 145·2	− 48·4	− 44·2	− 89·4
− 12·9	− 54·4	− 13·4	− 5·2	− 22·7	+ 27·5	− 7·4	+ 37·4	+ 20·0	+ 12·3	−122·3	− 206·2	−113·6	+165·9	−132·7
+ 92·6	+ 47·0	+ 69·3	+ 71·3	+ 69·5	+ 60·3	+ 81·2	+ 53·0	+ 66·2	+ 62·7	+ 51·5	+ 5·9	− 27·9	− 10·3	+ 3·3
+ 27·1	− 28·2	+ 19·5	+ 13·4	+ 6·9	+ 53·6	+ 2·9	+ 12·9	+ 26·3	+ 18·9	− 100·5	− 182·5	− 69·7	− 81·0	−108·4
+ 37·6	− 3·4	+ 21·3	+ 156·1	+ 52·9	− 0·8	+ 9·6	+ 19·5	+ 74·8	+ 29·8	− 27·4	− 152·6	− 35·1	− 14·3	− 57·4
+ 187·5	+321·2	+ 522·8	+1087·7	+ 529·8	−254·1	−182·9	−291·5	+ 31·5	−174·2	− 14·0	+ 230·3	+ 340·5	+240·1	+201·2
+ 9·5	− 89·9	− 19·3	− 24·4	− 31·1	+ 75·6	+ 4·4	− 4·8	+ 80·5	+ 38·2	+ 65·9	− 62·6	− 5·5	− 70·8	− 18·3
− 41·7	− 27·5	− 122·5	− 189·4	− 95·2	+ 7·0	− 3·7	+ 0·6	+ 5·7	+ 2·4	− 41·2	− 83·3	− 13·3	− 55·2	− 48·4
− 0·3	...	...	− 0·7	− 0·3	...	...	...	...	...	− 0·8	...	...	...	− 0·1
− 160·5	−137·8	− 22·3	...	− 61·0	− 54·2	+ 13·4	− 0·9	...	− 10·4	− 49·1	− 40·3	− 38·9	...	− 32·0
+1429·7	−183·3	+1107·0	+1693·9	+1011·8	+257·9	−373·3	+106·5	+ 599·2	+147·0	+ 724·5	− 643·1	+ 167·8	−417·4	− 42·0

Leguminosæ (continued).

− 15·7	− 8·7	− 5·9	− 2·7	− 7·7	+ 0·1	...	...	+ 0·4	+ 0·1	− 138·7	− 20·7	− 74·7	− 0·1	− 57·8
− 138·4	− 70·0	− 20·5	− 46·0	− 69·5	− 0·2	...	+ 1·1	+ 3·4	+ 1·1	− 901·3	− 211·6	− 98·9	+ 79·7	−158·9
− 55·4	− 75·7	− 96·0	− 92·1	− 79·8	− 1·4	− 7·7	− 8·6	− 2·8	− 5·2	− 55·7	− 28·2	− 6·3	− 0·7	− 22·8
− 23·2	− 22·7	+ 25·4	+ 221·0	+ 48·9	+ 9·4	− 0·3	+ 40·5	+ 275·5	+ 81·3	− 587·5	− 301·0	−1512·3	−340·6	−885·3
− 234·7	−179·1	− 103·0	+ 80·2	− 108·1	+ 7·9	− 8·0	+ 33·0	+ 276·5	+ 77·3	−1680·2	− 562·5	−1640·1	−417·1	−925·0

Other Orders (continued).

− 5·1	+152·9	+ 22·9	− 7·7	+ 40·7	− 19·8	+ 61·3	+ 44·1	+ 19·0	+ 23·9	− 65·3	− 159·9	+ 14·2	− 42·4	− 63·6
− 9·3	+ 25·0	+ 5·2	− 6·3	+ 3·6	− 0·4	− 85·6	− 15·0	+ 3·0	− 11·9	− 1·3	+ 9·5	+ 28·4	+ 13·5	+ 12·5
+ 102·0	− 4·2	+ 98·1	+ 23·6	+ 52·4	+ 87·5	− 1·5	+ 89·0	+ 67·9	+ 63·3	+ 73·9	− 103·7	− 106·1	+ 42·0	− 24·0
+ 400·4	+716·0	+ 182·9	+ 279·2	+ 418·6	+186·3	+247·7	+ 32·7	+ 260·5	+181·9	+ 446·2	+ 378·8	+ 162·4	− 16·8	+242·8
− 15·1	− 97·3	− 5·2	+ 23·2	− 23·6	+ 0·4	+ 2·5	+ 47·2	+ 62·2	+ 29·3	− 19·2	− 29·2	− 18·5	+ 39·5	− 6·9
− 359·5	−542·8	− 87·8	− 168·1	− 289·5	+ 68·0	− 5·3	− 29·5	− 15·7	+ 4·3	− 44·4	− 99·4	− 3·4	− 61·5	− 52·3
− 4·2	− 31·2	− 30·0	− 61·8	− 31·9	...	...	...	− 2·6	− 0·7	− 6·1	− 56·6	− 19·1	− 14·8	− 24·0
+ 206·0	+218·4	+ 174·0	+ 83·9	+ 170·3	+332·2	+269·3	+168·5	+ 304·3	+291·1	+ 383·7	− 60·4	+ 58·3	− 43·5	+ 84·5

Summary (continued).

+1429·7	−183·3	+1107·0	+1693·9	+1011·8	+257·9	−373·3	+106·5	+ 599·2	+147·0	+ 724·5	− 643·1	+ 167·8	−417·4	− 42·0
− 384·7	−179·1	− 103·0	+ 80·2	− 108·1	+ 7·9	− 8·0	+ 33·0	+ 276·5	+ 77·3	−1680·2	− 562·5	−1640·1	−417·1	−925·0
+ 206·0	+218·4	+ 174·0	+ 83·9	+ 170·3	+332·2	+269·3	+168·5	+ 304·3	+291·1	+ 383·7	− 60·4	+ 58·3	− 43·5	+ 84·5
+1400	−140	+1178	+1858	+1074	+598	−114	+308	+1270	+515	+ 28	−1266	−1414	−878	−882

It will be observed that, as was the case on plot 5, *Festuca ovina* remained by far the most prominent grass, and that its proportion increased in the last two separation-years, that is after the cessation of the application of the ammonia-salts, and the substitution of mineral manure; but the increase was not by any means so marked as it was on plot 5, with the continued supply of ammonia-salts. Again, as on plot 5, *Agrostis vulgaris* was very prominent; and, although it showed an increase in the third separation-year, it had decreased very much in the fourth, *Holcus lanatus* having gradually increased, and much exceeded it in that year; whilst on plot 5 *Holcus* declined very much in the later years. The only other grasses which seemed to become distinctly more prominent after the change were *Anthoxanthum odoratum* and *Dactylis glomerata*; whilst *Avena elatior* and *A. flavescens*, *Poa pratensis* and *P. trivialis*, and *Lolium perenne*, yielded fluctuating and small quantities; and *Avena pubescens*, which had yielded largely in the first separation-year, gave very little in the second, and but little more in the third and fourth. Thus, the most prominent grasses were of low agricultural repute, nor were they characteristically free-growers; they were, on the other hand, such as have generally gained prominence under conditions of defective luxuriance and maturation combined.

Among Leguminosæ, *Lathyrus pratensis* very soon showed considerable increase after the application of the mineral manure; but, neither in the complete separation-years, nor in the intermediate and subsequent partial separations, has it acquired anything like the same degree of prominence as on plot 7, with the continuous supply of the same mineral manure, including potass, from the commencement.

Among the Miscellaneæ there were five species which yielded more than 1 per cent. to the total produce in one or other of the separation-years; whilst there were seven in this category on both plots 5 and 7. Of these, as usual, *Rumex Acetosa* was by far the most prominent; but it contributed very much less in the later years, though still more than on plot 5. Next in order is *Achillea Millefolium*, which has increased since the change of manure; whilst *Conopodium denudatum* has diminished, but again not so much as on plot 5. *Luzula campestris* has, on the other hand, become more prominent. Lastly, *Galium verum*, and *Scabiosa arvensis*, which by their increase in the later years came into the list of prominence on plot 5, with the ammonia-salts alone continuously, did not do so on plot 6. Although on both plots the proportion of total Miscellaneæ has gone down considerably in the later years, it has done so in a less degree on plot 6 than on plot 5.

Comparing the actual yield per acre of the different groups and species with the produce without manure, the fluctuations were, as the result of the fluctuations in the seasons themselves, so great in the first two separation-years, that it is difficult to determine how much of the subsequent change is to be set down to change in the manure.

The best indications of the effects of the change will be found in the comparison of the yield on plot 6 with that on plot 5. Referring to the first two separation-years,

when the two plots were practically manured alike, it is seen that in the first, the Gramineæ, the Leguminosæ, and the Miscellaneæ, were each in excess on plot 6; whilst in the second the Gramineæ and Leguminosæ were in somewhat greater deficiency, but the Miscellaneæ were again in excess. After the change of manure on plot 6, there was in the first subsequent separation-year a slight, and in the second a great, increase of gramineous herbage. There was also in the first a slight, and in the second a greater, increase in the leguminous herbage; and, again, of miscellaneous herbage, there was a less amount of increase in the first, and a greater in the second.

Looking more to detail, the results show that in the fourth separation-year *Holcus lanatus* had then increased in yield, compared with plot 5, about as much as all the other grasses put together; and those which also increased in a greater or less degree in both the third and fourth separation-years are *Anthoxanthum odoratum*, *Avena elatior*, *A. pubescens*, *A. flavescens*, *Poa pratensis*, *P. trivialis*, and *Dactylis glomerata*, whilst *Lolium perenne* and *Festuca ovina* only gained in the fourth separation-year. On the other hand, *Agrostis vulgaris* declined in the fourth separation-year nearly as much as *Holcus lanatus* increased.

Of the leguminous produce on plot 6, which was much more in the fourth than in the third separation-year, and which in both cases consisted almost exclusively of *Lathyrus pratensis*, nearly the whole of the amount was in excess of that on plot 5.

Of Miscellaneæ there was, in each separation-year, more on plot 6 than on plot 5, so that the excess after the change of manure cannot be attributed exclusively to that change. The greatest excess on plot 6 is of *Rumex Acetosa*, next of *Achillea Millefolium*, then of *Luzula campestris*, and then of *Conopodium denudatum*.

Thus, the effect of the change from ammonia-salts to a complete mineral manure was to increase the yield of by far the majority of the grasses, and of *Holcus lanatus* especially, and to diminish that of only very few, but of these, *Agrostis vulgaris* considerably. It also increased the yield of the Leguminosæ, and somewhat perhaps that of the Miscellaneæ.

We have next to compare the yield of each group and species on plot 6, with the mixed mineral manure succeeding ammonia-salts, with that on plot 7, with the same mixed mineral manure every year from the commencement. The results contrast strikingly with those last referred to. Whilst, compared with plot 5, plot 6 gave an excess of almost every grass after the change, compared with plot 7 (with the continuous supply of the mineral manure including potass), there was a deficiency of almost every grass. Thus, in the third separation-year, plot 6 showed a deficiency in seven, but collectively a greater excess in five; and in the fourth separation-year a deficiency in nine, and an excess in three, the collective deficiency being very much greater than the excess in the third separation-year. The only grass which yielded considerably more with the supply of the mineral manure for the shorter period was the poorer *Festuca ovina*; whilst *Agrostis vulgaris* gave considerably less, as also did

Avena flavescens, and, in a less degree, *Poa trivialis*, *Lolium perenne*, *Avena pubescens*, *Holcus lanatus*, *Alopecurus pratensis*, *Poa pratensis*, and *Dactylis glomerata*. Thus, the grasses which are in defect with the less-continued supply of mineral manure are, for the most part, either of better quality, or of freer growth, than those which are in excess.

Of leguminous produce as a whole, there was very much less, as well as a greater or less deficiency of each species represented, with the less-continued supply of mineral manure, but the deficiency was by far the greatest in the case of *Lathyrus pratensis*. The yield of Leguminosæ on the plot previously receiving ammonia-salts—under the influence of which they were almost excluded—has, indeed, been much less during the subsequent 12 years of the application of the mixed mineral manure including potass, than it was during the first 12 years of the application of the same manure to plot 7, in this case succeeding upon the unmanured condition of soil, and the coincident more complex condition of the mixed herbage. It might be supposed that the reserve of nitrogen to be rendered available under the influence of the mineral manure would be greater during the 12 years succeeding the application of an excess of ammonia-salts than during the first 12 years of the application of the mineral manure on plot 7. The great relative deficiency in yield of Leguminosæ under the influence of the same manure applied upon a residue of ammonia-salts would seem to be explicable, therefore, on the supposition that the Leguminosæ had been to a great extent really banished during the 13 years' application of the ammonia-salts; whilst at the commencement of the experiment on plot 7 they were generally distributed, but of restricted growth, as is common without manure, or when the grasses are not forced into prominence by nitrogenous manures. That the deficient yield of Leguminosæ on plot 6 compared with plot 7 is due to a want of plant, and not (as it cannot be) to a corresponding deficiency of food material, is further rendered probable by the fact that, although the actual amount in each complete or partial separation-year since the change of manure on plot 6 is much less there than on plot 7, yet the amounts fluctuate somewhat correspondingly on the two plots from year to year according to season.

So much for the distinctions between the botany of plot 5 with the continuous supply of ammonia-salts, of plot 6 with ammonia-salts succeeded by mineral manure, and of plot 7 with the continuous supply of the same mineral manure from the commencement. The figures in the table, and the foregoing comments, however, bring to view very inadequately the very great differences between the herbage on the respective plots.

In the first season of the change of manure the herbage on plot 6 acquired a totally different aspect. Instead of the dark, almost blue, green colour, and restricted growth and development, which, in common with plot 5, it had, and which the latter still maintained, the Gramineæ showed a much less patchy and more uniform, though still not luxuriant, growth, grasses of small habit, as has been shown, still remaining prevalent; the colour was of a paler and more lively hue; there was more tendency to form stem and seed, and there was fuller and more even bottom growth. Leguminosæ

showed some signs of recovery and increasing tendency to ripen seed, as also did some of the Miscellaneæ.

From year to year these characters developed, the plot losing all semblance to plot 5 and gradually assimilating in character to plot 7; the chief difference between plots 6 and 7 being that the former did not show so conspicuous a development of Leguminosæ.

It will be necessary to make brief reference to the chemical history of the plots, and of their produce, in order to attain a clearer conception of the changes of result effected by the change of manuring. In the first place, in the first and second crops of the last 12 years, there has been about one and a-half time as much dry substance grown on plot 6, where mineral manure was substituted for ammonia-salts, as on plot 5, where the application of ammonia-salts was continued. Then again, it is found that as much nitrogen has been removed in the first crops of the 12 years since the change, from plot 6 to which no nitrogen has, during that period, been applied, as from plot 5, to which the application has been continued. But in five of the last six seasons second crops have also been removed from the land, and in these rather less nitrogen has been removed from plot 6 without, than from plot 5 with the continuous supply. The reason of this doubtless is that, whilst on plot 5 the first crops were leafy and unmatured, those of plot 6 were much more stemmy and ripe, and, therefore, the herbage was the more exhausted; to add to which disadvantage, there was also doubtless a less available store of nitrogen remaining. The result is, however, that there is only an average of between 3 and 4 lbs. less nitrogen yielded per acre per annum on plot 6, in the first and second crops taken together, than on plot 5. It is, however, remarkable, that even more nitrogen has been taken off in the produce of plot 7, to which none has been applied from the commencement (but only a mixed mineral manure including potass), than in that of either plot 5, to which more nitrogen was annually applied as ammonia-salts than was removed in the crops, or in that of plot 6, which had the same amount of ammonia-salts during the first 13 of the 25 years.

Further, the percentage of nitrogen in the dry substance of the produce is, since the change, very much lower in that of plot 6 than in that of plot 5. This indicates very much greater maturation, that is, very much more consolidation, or, in other words, under the influence of the mineral manure very much more carbon-assimilation in proportion to a given amount of nitrogen taken up. The percentage of nitrogen in the dry substance of the produce of plot 6 is indeed somewhat lower than in that of plot 7, owing to its less proportion of the more highly nitrogenous leguminous herbage.

In regard to the source of the large amount of nitrogen taken up on plot 7, where none has been applied, it was stated (Part I., p. 312) that, after the experiments had proceeded 20 years, the soil of plot 7 showed a considerably lower percentage of nitrogen than that either of the unmanured plot, or of the ammonia plot 5. That of plot 6 also showed a considerable reduction. The obvious inference is that, on plot 7 at any rate, nitrogen must, under the influence of the mineral manure, have

been obtained from the previously accumulated stores within the soil. It would seem, too, more than probable that the source of the continued large yield of nitrogen on plot 6, after the discontinuance of the application of the ammonia-salts, is also to be attributed, mainly at any rate, to a supply rendered available from earlier accumulations, rather than to the unrecovered residue of the previously applied ammonia-salts.

The mineral composition of the herbage as remarkably illustrates the difference in the character of growth as do the facts in regard to the nitrogen. Leaving fuller details on both points for the third or chemical part of our report, it may be stated that, even in the first year after the change, very much more total mineral matter, and especially very much more potass, and phosphoric acid also, was taken up on plot 6 than on plot 5. Indeed, over the 12 years since the change of manuring, nearly twice as much total mineral matter has been taken up in the first and second crops of plot 6 as in those of plot 5; but even on plot 6 less has been taken up than on plot 7 during the same period. Analytical details which are at command relating to the produce of the first seven of the last 12 years, show that it is of potass and phosphoric acid especially, that there has been a greatly increased accumulation by the growing plants; and it is these which, other things being equal, favour the tendency to stem- and seed-formation.

Thus, evidence of very various kinds concurs in showing that the effect of the change of manuring was not very strikingly to affect the distribution of species on the plot, and especially not to bring into prominence plants of free and luxuriant habit; but it was, on the other hand, very greatly to alter the character of development of the plants of meagre habit which had already possession of the soil. This remark applies especially to the grasses and to the Miscellaneæ, the effect on the Leguminosæ being, in a marked degree, to increase their predominance as well as to favour their maturing tendency.

15. *Equal nitrogen and equal potass, in nitrate of soda and sulphate of potass, and in nitrate of potass; in each case with superphosphate of lime; Plots* 19 *and* 20.

Having regard to the very marked effects of nitrate of soda, and of salts of potass, whether used separately or in conjunction, on the botanical composition, the luxuriance, and the character of development, of the mixed herbage, it seemed desirable to determine the comparative effects of a given amount of nitrate of potass, and of a mixture of nitrate of soda and sulphate of potass, containing the same amount of nitrogen and the same amount of potass. Accordingly, in 1872, plots 19 and 20 were set apart for experimenting on this point. The area appropriated had from the commencement been enclosed with the other experimental ground, and so protected from grazing by animals. It had been entirely unmanured for a number of years, and every year one crop of hay had been removed from it. To plot 19, 275 lbs. of nitrate of soda (the same amount as applied to plot 16) was applied; and to plot 20,

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TABLE LXXX.—Number of Species, Percentage, Quantity per Acre, &c., of each Species, by equal Nitrogen and equal Potass, in Nitrate of Soda and Sulphate of Potass (Plot 19), and in Nitrate of Potass (Plot 20), in each case with Superphosphate of Lime; Plots 19 and 20.

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	Number of Species, and proportion per cent.									Quantity per Acre.									Increase + or Decrease − compared :—																
																			With Plot 3, without manure.						With Plot 16.						With Plot 19.			
	Plot 16.		Plot 19.		Plot 20.		Mean of 1872 and 1877.			Plot 16.		Plot 19.		Plot 20.		Mean of 1872 and 1877.			Plot 16.		Plot 19.		Plot 20.		Mean of 1872 and 1877.			Plot 19.		Plot 20.		Mean of 1872 and 1877.			Plot 20.		
	1872.	1877.	1872.	1877.	1872.	1877.	Plot 16.	Plot 19.	Plot 20.	1872.	1877.	1872.	1877.	1872.	1877.	Plot 16.	Plot 19.	Plot 20.	1872.	1877.	1872.	1877.	1872.	1877.	Plot 16.	Plot 19.	Plot 20.	1872.	1877.	1872.	1877.	Plot 19.	Plot 20.	1872.	1877.	Mean.
NUMBER OF SPECIES.																																			
Gramineæ	17	15	16	16	15	16	16	16	16	...	...	...	...	...	...	...	...	...	0	− 2	− 1	− 1	− 2	− 1	− 1	− 1	− 1	− 1	+ 1	− 2	+ 1	0	0	− 1	0	0	Gramineæ.
Leguminosæ	4	4	4	4	4	4	4	4	4	...	...	...	...	...	...	...	...	...	0	0	+ 1	0	+ 1	0	+ 1	0	+ 1	0	0	+ 1	− 1	− 1	Leguminosæ.
Other Orders	15	22	20	18	22	18	20	19	20	...	...	...	...	...	...	...	...	...	− 13	− 9	− 8	− 13	− 6	− 13	− 11	− 11	− 10	+ 5	− 4	+ 7	− 4	0	+ 1	+ 2	0	+ 1	Other Orders.
Total	36	41	40	39	42	38	39	40	40	...	...	...	...	...	...	...	...	...	− 13	− 11	− 9	− 13	− 7	− 14	− 12	− 11	− 11	+ 4	− 2	+ 6	− 3	+ 1	+ 1	+ 2	− 1	0	Total.
GRAMINEÆ.																																			
Anthoxanthum odoratum	p. c. 1·40	p. c. 2·22	p. c. 0·39	p. c. 2·47	p. c. 1·17	p. c. 3·51	p. c. 1·81	p. c. 4·43	p. c. 5·34	lbs. 62·7	lbs. 135·2	lbs. 298·8	lbs. 116·3	lbs. 309·2	lbs. 180·6	lbs. 99·0	lbs. 201·3	lbs. 244·9	lbs. − 22·8	lbs. + 14·2	lbs. + 201·3	lbs. − 4·2	lbs. + 222·7	lbs. + 59·6	lbs. + 141·7	lbs. +224·1	lbs. − 18·5	lbs. +246·5	lbs. + 45·2	lbs. +102·8	lbs. +145·9	lbs. + 22·4	lbs. + 63·8	lbs. + 43·1	Anthoxanthum odoratum.
Alopecurus pratensis	19·52	12·73	7·48	5·40	11·73	7·91	4·63	5·34	4·01	661·1	748·8	102·5	200·3	82·6	349·2	713·2	132·9	201·2	+ 672·6	+ 738·5	+ 44·1	+ 342·7	+ 704·5	+ 125·0	+ 193·4	−670·8	−490·3	−628·5	−390·8	−580·5	−812·1	+ 42·3	+ 94·5	+ 68·4	Alopecurus pratensis.
Agrostis vulgaris	12·40	14·56	29·56	19·23	31·35	19·36	13·49	16·19	20·95	554·9	889·8	1147·1	512·0	1351·8	532·9	721·3	829·5	942·3	+ 289·6	+ 574·9	+ 881·8	+ 198·1	+ 1088·2	+ 219·0	+ 482·2	+ 539·9	+ 652·7	+592·2	+ 376·8	+786·9	−85·9	+107·7	+ 220·5	+ 294·7	+ 32·9	+ 112·9	Agrostis vulgaris.
Holcus lanatus	8·06	12·84	14·63	21·19	12·39	29·47	9·96	17·61	20·93	357·3	770·5	629·7	1001·9	534·5	1515·9	436·9	615·2	1025·7	+ 169·1	+ 472·8	+ 570·5	+ 709·3	+ 479·1	+ 1219·2	+ 321·0	+ 637·9	+ 847·2	+ 402·4	+ 231·4	+ 307·0	+ 745·4	+ 316·9	+ 526·2	− 89·4	+ 514·0	+ 209·2	Holcus lanatus.
Avena pubescens	1·94	2·34	1·90	3·00	1·92	2·40	2·44	2·25	1·71	86·9	203·8	87·2	141·2	44·0	123·4	136·2	104·5	83·7	+ 10·5	+ 140·0	+ 0·9	+ 78·2	− 14·4	+ 59·8	+ 75·3	+ 42·5	+ 22·7	− 1·6	− 61·6	− 24·9	− 80·2	− 33·3	− 52·6	− 22·3	− 18·4	− 20·8	Avena pubescens.
Avena flavescens	18·20	0·87	3·29	4·37	3·07	5·30	12·73	2·33	4·18	841·3	406·6	147·7	206·6	132·4	272·6	624·0	177·1	202·8	+ 783·9	+ 381·1	+ 90·3	+ 181·1	+ 75·0	+ 247·1	+ 582·6	+ 135·7	+ 161·1	−693·6	+ 2·0	−709·9	−134·0	−440·9	−417·5	− 18·9	− 66·2	− 41·5	Avena flavescens.
Poa trivialis	6·53	4·82	0·75	4·73	0·39	3·06	6·67	2·74	1·72	292·1	293·6	23·7	223·6	16·8	157·4	292·0	128·6	87·1	+ 284·0	+ 290·4	+ 25·5	+ 219·4	− 6·6	+ 144·2	+ 282·3	+ 117·9	+ 79·4	−256·5	− 70·2	−272·4	−136·4	−164·4	−235·9	− 17·1	− 55·7	− 36·4	Poa trivialis.
Dactylis glomerata	3·75	4·82	0·67	2·43	0·90	1·15	4·19	1·50	0·73	167·8	282·2	30·1	114·9	13·0	59·2	225·0	72·5	36·1	+ 153·0	+ 245·6	+ 15·3	+ 93·3	− 1·8	+ 42·6	+ 209·3	+ 80·9	+ 20·5	−137·7	− 167·3	−154·6	−223·0	−152·5	−188·9	− 2·9	− 42·4	− 22·7	Dactylis glomerata.
Cynosurus cristatus	0·05	0·18	1·17	2·54	1·15	1·51	0·72	1·96	1·33	2·2	11·0	52·5	120·1	49·6	77·7	6·8	86·3	63·6	− 16·0	− 12·2	+ 34·3	+ 36·9	+ 31·4	+ 54·5	− 14·1	+ 63·6	+ 42·9	+ 50·3	+ 109·1	+ 47·4	+ 68·7	+ 79·7	+ 57·0	− 2·9	+ 42·4	+ 22·7	Cynosurus cristatus.
Festuca ovina	10·33	10·66	29·65	21·40	20·54	18·69	13·49	20·32	22·13	462·3	1013·6	1290·7	1011·8	1101·3	961·5	738·9	1171·2	1551·4	+ 109·1	+ 490·1	+ 374·5	+ 494·3	+ 742·1	+ 444·0	+ 502·6	+ 584·6	− 54·1	+462·4	− 2·6	+437·3	+292·5	+239·4	+ 59·3	−139·9	Festuca ovina.
Lolium perenne	2·10	3·75	4·14	1·23	2·03	3·81	2·42	2·63	2·82	139·7	228·6	185·9	58·2	87·5	168·7	182·7	122·3	136·6	+ 90·7	+ 121·0	+ 146·8	− 49·4	+ 49·5	+ 78·1	+ 110·4	+ 48·7	+ 63·3	+ 47·1	− 170·4	− 51·2	+ 42·9	− 61·7	− 47·1	− 39·5	+ 127·5	+ 14·6	Lolium perenne.
Bromus mollis	2·03	0·87	...	...	...	...	1·30	...	...	90·9	34·7	...	...	...	...	62·8	...	...	+ 90·7	+ 34·7	...	...	...	...	+ 62·7	...	...	− 90·9	− 34·7	− 90·9	− 34·7	− 62·8	− 62·8	...	...	...	Bromus mollis.
None yielding 1 per cent. — Poa pratensis, Briza media, Festuca pratensis, Festuca laticsea, Phleum pratense, Aira cæspitosa, Avena elatior	0·85	0·65	1·24	1·36	0·75	0·25	0·76	1·31	0·51	39·0	29·7	55·5	64·3	32·2	12·8	38·9	60·1	22·6	− 71·2	− 135·7	− 53·7	− 111·8	− 77·0	− 162·6	− 103·5	− 92·7	− 119·9	+ 17·5	+ 24·6	− 8·8	− 26·9	+ 21·2	− 16·3	− 23·3	− 51·5	− 37·5	None yielding 1 per cent. — Poa pratensis, Briza media, Festuca pratensis, Festuca laticsea, Phleum pratense, Aira cæspitosa, Avena elatior
Absent — Phleum pratense (plots 16 and 19), Festuca laticsea (plots 16 and 20), Bromus mollis (plots 19 and 20)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	− 0·7	− 0·2	...	− 0·2	− 0·7	− 0·4	− 0·1	− 0·5	...	...	...	...	...	...	...	...	...	Absent. — Phleum pratense (plots 16 and 19), Festuca laticsea (plots 16 and 20), Bromus mollis (plots 19 and 20).
Undetermined (chiefly Gramineæ)	0·50	...	0·73	...	0·74	...	0·25	0·37	0·37	22·4	...	32·8	...	31·9	...	11·2	16·4	15·9	− 26·3	...	− 15·9	...	− 16·4	...	− 12·1	− 7·9	− 8·4	+ 10·4	...	+ 9·5	...	+ 8·2	+ 4·7	− 0·9	...	− 0·8	Undetermined (chiefly Gramineæ).
Total	81·58	82·94	89·35	80·95	87·12	86·11	82·26	85·15	86·61	3650·7	5066·0	4010·0	3827·3	3756·6	4429·5	4353·4	3918·6	4093·0	+2531·9	+3374·0	+2881·2	+2145·3	+2627·6	+2747·5	+2948·1	+2513·3	+2687·7	+359·3	−1229·7	+105·9	−626·5	−434·8	−260·4	−253·4	+602·2	+174·4	Total.
LEGUMINOSÆ.																																			
Trifolium repens	0·32	0·61	0·19	0·84	0·21	0·64	0·16	0·52	0·42	14·3	0·6	8·5	39·7	9·1	32·9	7·5	24·1	21·0	+ 8·1	− 2·5	+ 2·3	+ 36·6	+ 2·9	+ 22·8	+ 2·8	+ 19·4	+ 16·3	− 5·8	+ 39·1	− 5·2	+ 32·3	+ 16·6	+ 13·5	+ 0·6	− 6·3	− 3·1	Trifolium repens.
Trifolium pratense	0·43	0·11	1·20	0·90	0·43	0·05	0·27	1·05	0·24	19·3	0·7	52·4	37·8	37·2	2·6	12·0	48·1	14·9	+ 19·3	− 42·7	+ 30·8	− 11·6	− 0·4	− 46·8	− 29·5	+ 9·6	− 23·6	+ 39·1	+ 31·1	+ 7·9	− 4·1	+ 35·1	+ 1·9	− 31·2	− 35·2	− 33·2	Trifolium pratense.
Trifolium procumbens	...	...	...	...	0·01	...	...	...	0·01	...	...	...	...	0·4	...	...	...	0·2	...	...	...	...	+ 0·4	...	...	...	+ 0·2	...	...	+ 0·4	...	...	+ 0·2	+ 0·4	...	+ 0·2	Trifolium procumbens.
Lotus corniculatus	0·02	0·06	0·79	0·12	1·09	0·24	0·04	0·45	0·66	0·9	3·7	35·5	9·7	47·0	12·3	2·3	20·6	29·7	− 26·8	− 39·7	− 22·2	− 27·7	− 50·7	− 61·1	− 39·3	− 75·8	− 50·9	+ 34·6	+ 2·0	+ 40·1	+ 2·6	+ 19·3	+ 37·4	+ 11·9	+ 6·6	+ 9·1	Lotus corniculatus.
Lotus major	...	...	...	0·04	...	...	...	0·02	...	...	...	...	1·9	...	...	...	1·0	...	...	...	...	+ 1·9	...	...	...	+ 1·0	...	...	+ 1·9	...	...	...	...	− 1·9	− 1·0	Lotus major.
Lathyrus pratensis	6·68	9·22	0·23	6·92	0·10	2·73	7·95	3·57	1·42	299·9	562·0	10·3	237·2	4·3	140·5	430·4	168·7	72·4	+ 282·8	+ 506·0	− 5·8	+ 271·2	− 11·8	+ 34·5	+ 394·4	+ 132·7	+ 36·4	−286·6	− 234·8	−421·5	−261·7	−358·0	− 0·6	−186·7	− 96·3	Lathyrus pratensis.
Total	7·45	9·40	2·81	8·72	2·04	3·69	8·42	5·61	2·85	333·4	573·0	112·7	412·3	80·0	188·3	453·2	262·5	138·2	+ 185·8	+ 371·1	− 34·9	+ 210·4	− 59·6	+ 13·6	+ 278·4	+ 87·7	+ 30·6	−220·7	− 160·7	−245·4	−384·7	−190·7	−315·0	− 24·7	−224·0	−124·3	Total.
OTHER ORDERS.																																			
Ranunculus acris	0·79	1·24	0·20	0·81	0·91	0·19	1·91	0·45	0·10	35·4	75·6	13·5	29·3	0·4	9·3	35·5	21·2	3·1	+ 34·2	+ 75·6	+ 12·3	+ 28·9	− 0·9	+ 9·3	+ 34·9	+ 20·6	+ 4·5	− 21·9	− 66·3	− 35·0	− 63·3	− 34·3	− 50·4	− 13·1	− 19·0	− 16·1	Ranunculus acris.
Ranunculus repens et bulbosus	0·33	0·28	2·02	0·19	3·93	3·83	0·29	1·10	2·86	14·8	15·8	50·7	9·0	169·5	197·0	15·3	49·8	183·2	− 33·5	− 65·8	+ 42·4	+ 72·6	+ 121·2	+ 110·4	− 49·6	− 16·1	+ 118·3	+ 75·9	− 6·8	+154·7	+181·2	+ 34·5	+167·9	+ 78·6	+188·0	+ 133·4	Ranunculus repens et bulbosus.
Conopodium denudatum	3·90	0·51	1·96	4·47	2·02	2·66	2·20	3·21	2·34	174·9	81·1	89·0	211·3	87·1	136·8	102·9	149·6	111·9	+ 127·7	− 13·8	+ 41·2	+ 168·4	+ 40·3	+ 91·9	+ 87·0	+ 102·8	+ 66·1	− 86·5	+ 180·2	− 87·4	+ 105·7	+ 46·8	+ 9·1	− 0·9	− 74·5	− 37·7	Conopodium denudatum.
Centaurea nigra	1·14	0·31	0·06	0·67	0·91	0·16	0·72	0·66	0·86	51·0	18·9	2·6	2·3	0·4	4·2	34·9	2·5	4·3	+ 16·4	− 6·2	+ 31·0	− 21·9	− 3·4	+ 2·6	+ 5·1	− 26·3	− 25·5	− 47·4	− 15·6	− 50·6	− 10·7	− 31·4	− 20·6	− 2·2	+ 4·9	+ 0·6	Centaurea nigra.
Achillea Millefolium	3·29	1·55	0·65	0·95	0·75	0·95	2·42	0·87	0·79	147·2	94·5	30·5	31·2	32·7	41·1	120·8	30·6	37·4	+ 117·9	+ 47·5	+ 1·2	+ 19·8	+ 4·4	+ 8·9	+ 82·7	+ 7·3	− 11·3	− 113·5	+ 53·4	− 30·0	+ 83·4	+ 3·2	+ 9·3	+ 6·6	Achillea Millefolium.
Rumex Acetosa	1·19	2·19	0·72	2·85	1·39	1·51	1·89	1·68	1·38	53·3	133·5	32·3	125·3	54·4	77·7	93·4	78·8	68·0	+ 24·2	+ 59·3	+ 3·2	+ 81·1	+ 28·3	+ 33·5	+ 56·7	+ 42·1	+ 29·3	− 21·6	− 8·2	+ 1·1	− 55·9	− 14·6	− 27·4	+ 22·1	− 47·6	− 12·9	Rumex Acetosa.
Lamium camposeris	0·06	0·16	1·42	0·33	2·02	0·36	0·11	0·87	1·19	2·7	9·6	63·9	15·6	87·1	18·5	6·3	39·7	52·6	− 53·5	− 32·0	+ 7·6	− 26·2	+ 30·9	− 22·3	− 42·7	− 9·3	+ 8·8	+ 61·1	+ 5·8	+ 84·4	+ 8·7	+ 33·4	+ 46·5	+ 23·3	+ 2·9	+ 13·1	Lamium camposeris.
None yielding 1 per cent. — Ranunculus auricomus, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Pimpinella Saxifraga, Heracleum Sphondylium, Anthriscus sylvestris, Galium verum, G. Aparine, Bellis perennis, Tragopogon pratensis, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Prunella vulgaris, Ajuga reptans, Primula veris, Scilla autans, Carex præcox, Ophioglossum vulgatum, Hypnum squarrosum, H. triens, H. rutabulum	0·27	1·44	0·96	1·35	0·81	0·72	0·88	1·18	0·78	12·0	87·9	42·9	63·9	34·8	37·1	49·9	53·5	36·1	− 63·5	− 33·8	− 46·4	− 68·7	− 56·9	− 96·9	− 48·7	− 57·7	− 76·9	+ 31·0	− 22·9	+ 22·9	− 50·7	+ 2·6	− 14·0	− 8·1	− 26·8	− 17·4	None yielding 1 per cent. — Ranunculus auricomus, Stellaria graminea, Cerastium triviale, Potentilla reptans, Agrimonia Eupatoria, Pimpinella Saxifraga, Heracleum Sphondylium, Anthriscus sylvestris, Galium verum, G. Aparine, Bellis perennis, Tragopogon pratensis, Taraxacum officinale, Plantago lanceolata, Veronica Chamædrys, Prunella vulgaris, Ajuga reptans, Primula veris, Scilla autans, Carex præcox, Ophioglossum vulgatum, Hypnum squarrosum, H. triens, H. rutabulum
Absent — Poterium Sanguisorba, Scabiosa arvensis, Chrysanthemum Leucanthemum, Leontodon hispidus, Hieracium Pilosella, Thymus Serpyllum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	− 46·6	− 73·9	− 32·3	− 62·9	− 30·4	− 61·5	− 60·4	− 47·7	− 48·0	...	...	...	...	...	...	...	...	...	Absent — Poterium Sanguisorba, Scabiosa arvensis, Chrysanthemum Leucanthemum, Leontodon hispidus, Hieracium Pilosella, Thymus Serpyllum.
Total	10·97	7·66	8·14	10·33	10·64	10·23	9·32	9·24	10·54	490·9	467·0	365·3	499·4	467·4	526·2	478·9	429·9	496·8	+ 123·3	− 13·1	− 2·3	+ 8·3	+ 99·8	+ 46·1	+ 55·0	+ 3·0	+ 72·9	−125·6	+ 21·4	− 23·5	+ 59·2	− 52·0	+ 17·9	+102·1	+ 37·8	+ 69·9	Total.
SUMMARY.																																			
Gramineæ	81·58	82·94	89·35	80·95	87·12	86·11	82·26	85·15	86·61	3650·7	5066·0	4010·0	3827·3	3756·6	4429·5	4353·4	3918·6	4093·0	+2531·9	+3374·0	+2881·2	+2145·3	+2627·6	+2747·5	+2948·1	+2513·3	+2687·7	+359·3	−1229·7	+105·9	−626·5	−434·8	−260·4	−253·4	+602·2	+174·4	Gramineæ.
Leguminosæ	7·45	9·40	2·81	8·72	2·04	3·69	8·42	5·61	2·85	333·4	573·0	112·7	412·3	80·0	188·3	453·2	262·5	138·2	+ 185·8	+ 371·1	− 34·9	+ 210·4	− 59·6	+ 13·6	+ 278·4	+ 87·7	+ 30·6	−220·7	− 160·7	−245·4	−384·7	−190·7	−315·0	− 24·7	−224·0	−124·3	Leguminosæ.
Other Orders	10·97	7·66	8·14	10·33	10·64	10·23	9·32	9·24	10·54	490·9	467·0	365·3	499·4	467·4	526·2	478·9	429·9	496·8	+ 123·3	− 13·1	− 2·3	+ 8·3	+ 99·8	+ 46·1	+ 55·0	+ 3·0	+ 72·9	−125·6	+ 21·4	− 23·5	+ 59·2	− 52·0	+ 17·9	+102·1	+ 37·8	+ 69·9	Other Orders.
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	4475	6096	4488	4739	4312	5144	5285	4808	4728	+2831	+3732	+2944	+2364	+2988	+2780	+3231	+2804	+2724	+ 13	−1368	−163	−952	−677	−557	−176	+416	+120	Total.

327 lbs. of nitrate of potass, containing the same amount of nitrogen as the 275 lbs. of nitrate of soda. To plot 19 was also applied 290 lbs. of sulphate of potass, containing the same amount of potass as in the 327 lbs. of nitrate of potass supplied to plot 20. To both plots superphosphate, in the same amount as used on other plots of the series, was also applied.

Thus, so far as nitrogen, as nitrate, and superphosphate, are concerned, the two plots, 19 and 20, were manured precisely as plot 16 had been for 14 preceding years, and as it continued to be subsequently. Plot 16 received, however, about 5 lbs. per acre per annum more potass, and some sulphate of soda and sulphate of magnesia in addition. The only difference between the manuring of plots 19 and 20 was, that plot 19 received the soda of the nitrate, and the sulphuric acid of the sulphate of potass, in addition to the constituents supplied to plot 20. On the other hand, plot 20 received its nitric acid and its potass in combination.

The folding Table (LXXX.) shows the percentage and the acreage particulars of each group and species for plots 16, 19, and 20, in the last two complete separation-years (1872 and 1877), the experiments of 19 and 20 only commencing in 1872. There is also given, the difference between the produce on each, compared with that on plot 3 without manure; and plots 19 and 20 are each compared with plot 16, and with one another.

In each of the two separation-years each of the three plots 16, 19, and 20 shows considerably fewer species than the unmanured plot 3; the deficiency being almost exclusively in the Miscellaneæ. Plot 16, which has been the longer under treatment, shows a slightly greater average deficiency in number, and both 19 and 20 show a greater reduction in number in the second than in the first of the two separation-years. The actual number of species found in the samples in the two separation-years was, in those from plot 16, 36 and 41; in those from plot 19, 40 and 39, and in those from plot 20, 42 and 38.

According to the determinations in the complete separation-years, both plots 19 and 20 show a higher average percentage of Gramineæ than plot 16, but, according to the subsequent partial separations, plot 16 indicates the higher proportion in the first, but not in the second crops. Of Leguminosæ, the older plot, 16, which received rather more of potass, and some other mineral constituents, gave a higher percentage in the earlier seasons (especially in the complete separation-years), but according to the subsequent partial separations a less proportion in the later seasons. In the period prior to that of our comparison, plot 16 gave a much higher percentage of Miscellaneæ than subsequently, but in the later years it has, on the average, given less than on either plot 19 or 20; and plot 19, with the nitrate of soda and sulphate of potass, has each year given a less proportion than plot 20 with the nitrate of potass.

Referring to individual species, the table shows that on both plots 19 and 20 the two prevalent grasses of the locality under poor conditions, *Festuca ovina* and *Agrostis vulgaris*, were by far the most prominent in the first of the two separation-years. In

the second, however, they had each declined considerably, whilst on both, but especially with the nitrate of potass, *Holcus lanatus* had very considerably gained ground. These three grasses were also among the most prominent on plot 16. On that plot, however, *Alopecurus* had become very characteristic; whilst on plots 19 and 20 it did, it is true, increase very considerably from the first to the second separation-year, but still yielded a much less proportion than on plot 16. The other grasses of chief prominence on plot 16 were *Avena flavescens*, *Poa trivialis*, and, in a less degree, *Dactylis glomerata* and *Lolium perenne*. Of these, *Avena flavescens*, *Poa trivialis*, and *Dactylis glomerata*, had each increased on plots 19 and 20, but neither had acquired the same prominence as on plot 16. In the later years, however, the notes indicated that, as on plot 16, *Avena flavescens* became more prominent on both plots; whilst *Lolium perenne* decreased on 19 with the nitrate of soda, but increased on 20 with the nitrate of potass. *Anthoxanthum odoratum* was much the higher on both the newer experimental plots, but on both it declined very much from the one separation-year to the other. *Avena pubescens* was meagrely, but about equally and increasingly represented on the three plots; whilst the poor *Cynosurus cristatus*, a poor-land grass, was more prominent on the two plots the most recently reclaimed from the unmanured condition.

According to the figures in the table, Leguminosæ considerably increased on both plots 19 and 20 from the first to the second separation-year; but much more on plot 19 with nitrate of soda than on plot 20 with nitrate of potass, and this relative excess on plot 19 continued, as is shown by the partial separations of later years. As in other cases of increase of Leguminosæ under the influence of a potass manure, *Lathyrus pratensis* is by far the most prominent constituent. As already intimated, however, the later partial separations further show that the Leguminosæ have considerably declined on plot 16, and are now more prominent on both 19 and 20, and more so again on 19 with the nitrate of soda, than on 20 with the nitrate of potass. According to the complete separations, *Lathyrus pratensis* is seen to be the most prominent leguminous species on all three plots, so far as final weight is concerned; but according to the notes taken on the ground during growth, *Trifolium pratense* or *T. repens* showed considerable prominence on the two newer plots; *T. pratense* being the more prominent with the more rapidly distributing nitrate of soda; and *T. repens* the more so with the probably more superficially retained, and less deeply distributing, nitrate of potass. The greater prominence of the *Lathyrus* in the samples is no doubt partly accounted for by the fact that a larger proportion of its produce would be included in the crop as mown, whereas a considerable proportion of the *Trifoliums* would be left uncut. At any rate, it is clear that Leguminosæ are favoured on all three plots; and it would seem more so with the nitrate of soda and sulphate of potass than with the nitrate of potass. Whether the decline on all three in the later years (subsequent to the last complete separation), but the more on the plot which has been the longer under treatment, be due to an exhaustion of the plants, and to the increased competition with the grasses, under the influence of the manure, and especially of the

nitrate, or whether it is merely a temporary effect of seasons more favourable to their competitors, remains to be proved.

As the table shows, there are seven Miscellaneæ which have yielded 1 per cent. or more to the total produce in one or other of the separation-years on one or other of the three plots 16, 19, 20. But the species reaching this degree of prominence are not the same on the three plots. There were, in fact, in the two years in question, only five which did so on plot 16, and only four which did so on either 19 or 20. These were on the respective plots as shown below; and as the results of a single season might be misleading, they are in each case given in the order, not as in the latest separation-year, but of their average prominence over the two years:—

Plot 16.	*Plot* 19.	*Plot* 20.
Achillea Millefolium.	Conopodium denudatum.	Ranunculus repens and bulbosus.
Conopodium denudatum.	Rumex Acetosa.	Conopodium denudatum.
Rumex Acetosa.	Ranunculus repens and bulbosus.	Rumex Acetosa.
Ranunculus acris.	Luzula campestris.	Luzula campestris.
Centaurea nigra.		

It will be observed that, on the older and somewhat more fully mineral-manured plot 16, *Achillea Millefolium* is the first, and *Centaurea nigra* the last on the above list; whilst neither of them comes into the category on either 19 or 20. On the other hand, *Luzula campestris* is the fourth in average prominence (but much declining) on both 19 and 20, but does not come into the list of 16. Of the remaining plants enumerated, two are the same on the three plots, and the others belong to the same genus, though not to the same species. Among these, *Conopodium* is first on the nitrate of soda plots 16 and 19, and second on the nitrate of potass plot 20; *Rumex Acetosa* is second on 16 and 19, but third on 20; *Ranunculus acris* is third on 16; *R. repens* and *R. bulbosus* third on 19, and first on 20. Too much stress should not, however, be laid on the exact degree of prominence indicated by the figures, as these clearly show that there is great fluctuation according to season as well as according to manure.

As between plot 19, with the nitrate of soda and sulphate of potass, and plot 20 with the nitrate of potass, it is worthy of remark that, on the former, on which it is to be presumed the nitrate would distribute the more rapidly and the more deeply, the deeper-rooting *Ranunculus acris* maintains (at the second separation) a greater prominence than *R. repens* and *R. bulbosus*; whilst with the nitrate of potass, which would be less diffusible, the more superficially-rooting *R. repens* and *R. bulbosus* maintain much the higher degree of prominence. Consistently also, the deep-rooting *Conopodium denudatum* and *Rumex Acetosa* attain a greater prominence on the nitrate of soda plot. On neither of the newer plots is *Achillea Millefolium* so prominent as on the older one (16); whilst *Luzula*, as already referred to, has, so far, greatly declined on both.

So far as the Miscellaneæ are concerned, the general result on both plots would seem to be, as was the case with the Gramineæ, to approximate more nearly to the condition of plot 16. With the longer continuance of the treatment on plot 16, and with an increasing competition on the part of the grasses and Leguminosæ, the Miscellaneæ collectively declined to a lower point on it than on either of the two plots more recently brought under experiment. The previously most prominent species on plot 16, *Conopodium*, *Rumex*, and *Achillea*, on it declined, but, so far, they have either increased or remained stationary on the newer plots.

Referring to the actual yield per acre on the three plots, though there is considerable fluctuation in the amount of produce contributed by the three main groups of plants, plot 16 has, on the average, not only of the two complete separation-years, but also including those of partial separation, yielded considerably more total gramineous herbage, more leguminous herbage, and about the same amount of miscellaneous.

It would be of little use to compare the actual produce of individual species on the three plots with that without manure, though the results are given for reference in the table. The comparison of the produce of the different groups and species on each of the two new plots with that on 16, is of much more interest. The most striking points indicated are that, although there was a much greater amount of both *Agrostis vulgaris* and *Festuca ovina* on both plots 19 and 20 than on plot 16 in the first separation-year (1872, which was also the first year of the experiments on 19 and 20), there was, in the second separation-year (1877), on both a less amount, especially of *Agrostis vulgaris*. The fact is, that whilst both these grasses had increased considerably from the first to the second of these two separation-years on the older plot 16, each greatly diminished from its higher original amount on plots 19 and 20. *Alopecurus pratensis* again showed on both the new plots, and in both seasons, a great deficiency compared with plot 16, although on both it showed an actual and considerable increase. *Holcus lanatus*, on the other hand, was in much greater, and in more rapidly increasing, amount on the two plots 19 and 20 than on 16; and it increased very much the more largely on the nitrate of potass plot 20, where in the second separation-year it contributed more than a third of the total gramineous herbage. *Avena flavescens* also, especially in the first year, yielded considerably less on plots 19 and 20 than on the older plot 16, though on both it rather increased in actual amount. *Dactylis glomerata*, *Lolium perenne*, and *Avena pubescens*, were also each more or less in deficiency on plots 19 and 20. *Cynosurus cristatus* and *Anthoxanthum odoratum* were, on the other hand, in some excess. It was, in fact, in the poorer grasses—*Festuca ovina*, *Agrostis vulgaris*, and *Holcus lanatus*—that the two newer plots showed the greatest excess over plot 16 in the first of the two separation-years. In the second separation-year, however, there was either a deficiency, or a less excess of these, as compared with their yield on plot 16; whilst those which were in the greatest deficiency in the first separation-year on the newer plots compared with the older one, were the better grasses *Alopecurus pratensis* and *Avena flavescens*, each of

which had gained, both in actual and relative amount, compared with 16, by the second separation-year. Indeed, so far as the actual yield of the different grasses is concerned, the two newer plots in the main approximated to the character of the older one.

So far as the actual yield of the leguminous species is concerned, the most marked distinction between the older plot and the two newer ones is, that on the latter, *Lathyrus pratensis* is in considerable deficiency, whereas the different species of *Trifolium* have been hitherto mostly in excess.

Looking to the actual yield of the miscellaneous species, *Conopodium denudatum* alone comes to yield markedly more on the newer than on the older nitrate of soda plot, most of the other species yielding less. With the nitrate of potass, on the other hand, *Ranunculus repens* and *bulbosus*, as well as *Conopodium denudatum*, yield an excess.

The last three columns of the table bring to view the excess or deficiency in actual yield of each group or species of plant on plot 20 as compared with plot 19. They show that on plot 20, with the nitrate of potass, there was among the grasses a strikingly greater tendency to increase in the comparatively shallow-rooting *Holcus lanatus*, and some tendency to increase in *Lolium perenne*, *Alopecurus pratensis*, *Avena flavescens*, *Agrostis vulgaris*, and *Anthoxanthum odoratum*. There was, however, with the nitrate of potass a tendency to less produce of *Poa trivialis*, *Dactylis glomerata*, *Festuca ovina*, *Cynosurus cristatus*, and *Avena pubescens*. But the differences are, excepting in the very marked instance of the *Holcus*, too small to be thoroughly relied on in forming a judgment as to the different tendencies on the two plots.

Of total Leguminosæ there was notably less on plot 20 than on plot 19. There was, somewhat characteristically, a deficiency of the deeply-rooting *Trifolium pratense;* but there was at the same time a greater deficiency in the more surface-feeding *Lathyrus pratensis*.

Comparing the actual yield of miscellaneous species on plot 20 with that on plot 19, the most striking differences are, that with the less rapidly diffusing nitrate of potass, the comparatively superficially-rooting *Ranunculus repens* and *bulbosus* give a considerable excess, whilst the more deeply-rooting *Conopodium denudatum* and *Rumex Acetosa* are relatively in defect.

Taking the whole period of nine years, the general result has been that, with equal nitrogen on the three plots, but with more mineral supply on plot 16, which has also been under the same conditions of experiment for 14 preceding years, it showed annually more total growth, that is, yielded more total produce, containing more nitrogen, and more total mineral constituents, than either of the newer plots 19 or 20. Again, plot 19, with rather fuller mineral supply than plot 20, has yielded slightly more produce, more nitrogen, and more mineral matter. The deficiency of total growth on the newer plots was chiefly in the grasses, but somewhat in the Leguminosæ also.

Upon the whole, the tendency of change on the new plots was such as to bring them more nearly to the condition of the older one. All three plots, with only

moderate supply of nitrogen, in the form of nitrate (which is more favourable for plants of various habits and root-ranges than are ammonia-salts), and with, at the same time, an abundance of the most important mineral constituents, show fairly mixed herbage, with no excessive predominance of the poorer grasses of the locality, and a fair proportion, and amount, of a number of others of freer growth and better repute. There is at the same time a tendency to increase in the proportion and yield of the Leguminosæ. On the older plot there is a reduction in the proportion and amount of the Miscellaneæ; and on the newer ones there are, it is true, fluctuations from one season to another, but as yet without very marked tendency either to increase or to decrease. The herbage is, upon the whole, more mixed on the older plot than upon either of the newer plots, and perhaps it is the more so on plot 19 with the nitrate of soda, than on plot 20 with the nitrate of potass.

Comparing the flora of the two newer plots, the differences, such as they are, are seen to be consistent with the slight difference in the character of the manures employed. The most marked points which have been brought out are that the less diffusible nitrate of potass has brought the superficially-rooting *Holcus lanatus* into very great relative prominence; it has, however, much less favoured the comparatively surface-feeding *Lathyrus pratensis* than has the mixture of nitrate of soda and sulphate of potass. More consistently it has been less favourable to the deeper-rooting *Trifolium pratense*. Again, the more diffusible nitrate of soda has favoured the development of the deeply-rooting *Ranunculus acris;* whilst the less diffusible nitrate of potass has, in a much greater degree, enhanced the growth of the more superficially-rooting *R. repens* and *R. bulbosus*. Another point of distinction between the action of the two closely allied manures, as will be brought out more fully when treating of the chemical results, is that with the nitrate of potass, more of potass, though less of most other mineral constituents, is taken up; and, with this increase of potass, there is a somewhat greater tendency to stem-formation and maturation.

16. *Mixture supplying the ash-constituents, and the nitrogen, of one ton of hay; Plot* 18.

This experiment was not commenced until 1865, that is nine years later than most of the series. As explained more fully in Part I., p. 362, it had for its chief object to test the validity of the principle of manuring enunciated by Liebig, according to which all the constituents removed in crops, or contained in those it is wished to grow, and neither more nor less than are so removed or contained, should be returned to the soil, if the produce is to be maintained, or more should be supplied if it is to be increased. In his earlier application of the principle he limited this necessary return or supply to the mineral or ash-constituents of the crops removed or to be grown. Another object was to determine how much of the several constituents annually supplied would be recovered in the increase of crop.

The plan of experiment adopted was, to supply not only as much of each of the mineral constituents, but also as much nitrogen, as would be contained in one ton of hay, and to estimate the amount of increase of produce, and of the constituents contained in that increase. In carrying out the experiments, the constituents were supplied in chloride of potassium, sulphate of magnesia, bone-ash and sulphuric acid mixed as superphosphate, silicate of soda, silicate of lime, and ammonia-salts. The quantities of these supplied contained, as nearly as could be calculated, the full amount of potass, magnesia, lime, phosphoric acid, silica, and nitrogen, contained in one ton of hay of average composition; and the quantities of the various substances requisite for this supplied at the same time a considerable excess of soda, sulphuric acid, and chlorine.

Stated broadly, the result is that there was, up to 1880 inclusive, that is, over 16 years, so far as can be calculated, only about three-fourths of a ton instead of one ton of annual increase of produce due to the manure. This was so, notwithstanding that the nitrogen as well as the mineral constituents of a ton of hay had been annually supplied. Of the nitrogen supplied, only about half, but of most of the mineral constituents more than half of those supplied, are estimated to have been recovered in the increase. As pointed out in Part I., however, as the flora changed considerably compared with that without manure, there is some uncertainty in the estimation of the produce, and of its constituents, which are to be referred to increase due to the manure. Thus, under the influence of the manure, there is a much larger proportion and amount of gramineous herbage, which, though it contains a comparatively low percentage of nitrogen, is nevertheless greatly influenced by nitrogen artificially supplied; and hence the proportion of that supplied which was actually taken up, and contributed to the increase, may be greater than is estimated. But it may be observed that a less proportion of some of the more important mineral constituents—potass, for example—was recovered, with this carefully balanced but not excessive supply, than when larger quantities of mineral matter and nitrogen were applied, and when greater general luxuriance was, in consequence, induced.

The first year of the experiment being 1865, which was the tenth of the main series, we have the results of three complete botanical separations—in 1867, 1872, and 1877. The percentage and acreage results of these are given in the following Table, LXXXI., p. 1402; as also is the increase in actual yield of the various component species, over that on the unmanured plot 3, in the same seasons.

TABLE LXXXI.—Number of Species, Percentage, Quantity per Acre, &c., of each Species, by a Mixture supplying the Ash-constituents, and the Nitrogen, of 1 ton of Hay; Plot 18.

	Number of species, and proportion per cent.				Quantity per acre.				Increase + or decrease − compared with Plot 3.			
	1867.	1872.	1877.	Mean.	1867.	1872.	1877.	Mean.	1867.	1872.	1877.	Mean.
NUMBER OF SPECIES.												
Grasses	15	18	14	16	...	...	...	...	0	+1	− 3	0
Leguminosæ	4	4	4	4	...	...	...	...	0	0	0	0
Other Orders	21	22	21	21	...	...	...	...	−2	−6	−10	−7
Total	40	44	39	41	...	...	...	...	−2	−5	−13	−7
GRAMINEÆ.	p. c.	p. c.	p. c.	p. c.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Anthoxanthum odoratum	4·94	7·11	9·64	9·89	214·0	360·9	360·6	359·8	− 74·0	+ 190·4	+ 367·9	+ 124·6
Agrostis vulgaris	7·29	21·95	16·40	15·21	315·9	620·9	736·0	624·9	+ 27·9	+ 450·6	+ 434·1	+ 330·0
Holcus lanatus	12·76	7·32	17·45	12·55	552·9	372·9	780·2	557·3	+ 265·1	+ 214·6	+ 458·5	+ 312·3
Avena pubescens	2·87	2·58	1·94	2·46	124·4	69·5	87·3	102·7	+ 22·0	+ 82·1	+ 23·7	+ 27·9
Avena flavescens	2·42	3·75	3·12	4·09	140·1	215·1	140·4	167·9	+ 80·1	+ 187·7	+ 114·9	+ 119·6
Poa trivialis	4·82	2·82	2·90	2·92	209·2	159·7	129·9	149·1	+ 170·2	+ 101·0	+ 112·9	+ 128·0
Dactylis glomerata	1·79	1·20	1·29	1·42	77·5	44·9	57·6	60·0	+ 19·5	+ 30·1	+ 41·0	+ 30·2
Festuca ovina	7·06	23·76	24·65	18·49	306·4	868·5	1109·2	767·7	− 201·1	+ 632·3	+ 501·7	+ 307·6
Lolium perenne	6·15	9·97	9·45	8·39	229·1	126·0	250·6	213·1	+ 69·8	+ 87·0	+ 162·6	+ 119·8
None yielding 1 per cent. — Alopecurus pratensis, Phleum pratense, Aira cæspitosa, Avena elatior, Poa pratensis, Briza media, Cynosurus cristatus, Festuca pratensis, Bromus mollis	2·23	4·04	1·45	2·59	96·9	151·2	62·4	104·5	− 138·5	+ 15·1	− 140·3	− 87·9
Absent — Festuca loliacea	...	...	...	...	...	...	...	...	...	...	− 0·7	− 0·2
Undetermined (chiefly Graminea)	3·11	0·40	...	1·20	134·9	29·9	...	54·9	− 69·7	− 19·8	...	− 29·5
Total	55·49	89·89	84·18	72·48	2402·4	3021·9	3782·1	3070·9	+ 219·2	+1899·1	+2100·1	+1406·1
LEGUMINOSÆ.												
Trifolium repens	0·42	0·56	0·62	0·54	18·2	21·7	1·4	13·8	+ 11·2	+ 15·5	− 1·7	+ 8·4
Trifolium pratense	2·65	2·54	2·20	1·37	122·1	29·2	9·0	53·9	+ 81·6	− 7·4	− 6·4	+ 4·7
Lotus corniculatus	0·71	1·38	0·26	0·78	30·7	51·6	11·7	31·3	− 47·6	− 49·1	− 51·7	− 50·5
Lathyrus pratensis	0·83	1·07	1·90	1·13	36·0	40·0	87·9	47·9	+ 13·3	+ 23·9	+ 11·5	+ 16·2
Total	5·01	2·37	1·99	3·82	217·0	133·5	89·6	146·7	+ 58·7	− 14·1	− 113·3	− 29·2
OTHER ORDERS.												
Ranunculus repens et bulbosus	5·73	3·11	2·56	3·80	248·2	116·3	115·2	159·9	+ 181·2	+ 88·0	+ 29·6	+ 94·2
Cerastium semidecan	2·49	2·43	2·12	2·80	109·2	90·6	142·0	101·2	+ 61·6	+ 62·7	+ 56·1	+ 57·9
Achillea Millefolium	0·76	4·06	1·32	2·04	32·9	151·9	59·4	81·4	− 8·8	+ 122·6	+ 12·4	+ 42·1
Plantago lanceolata	2·79	0·94	0·05	0·96	120·9	1·5	2·2	41·5	− 236·6	− 42·3	− 72·6	− 117·1
Rumex Acetosa	24·23	1·97	4·62	10·21	1044·6	72·7	209·7	442·4	+ 889·5	+ 44·8	+ 152·5	+ 361·8
Lamium amplexic	0·44	1·73	0·04	0·73	19·1	64·9	1·8	28·4	− 101·3	+ 9·1	− 40·1	− 44·4
None yielding 1 per cent. — Ranunculus acris, Stellaria graminea, Cerastium triviale, Potentilla reptans, Pimpinella Saxifraga, Heracleum Sphondylium, Galium verum, G. Aparine, Centaurea nigra, Carduus arvensis, Bellis perennis, Chrysanthemum Leucanthemum, Trifolium pratense, Taraxacum officinale, Hieracium Pilosella, Veronica Chamædrys, Prunella vulgaris, Sella nutans, Carex præcox, Hypnum squarrosum, H. triste, H. rotundifolium	1·79	2·21	2·02	2·06	77·4	86·5	91·0	84·9	− 132·8	+ 1·8	+ 2·9	− 30·8
Absent — Agrimonia Eupatoria, Potentilla Tormentilla, Scabiosa arvensis, Leontodon hispidus, Thymus Serpyllum, Ajuga reptans	...	...	...	...	...	...	...	...	− 28·6	− 29·5	− 37·9	− 32·7
Total	39·53	15·63	13·23	23·00	1712·4	584·6	622·3	973·1	+ 742·1	+ 217·0	+ 142·2	+ 367·1
SUMMARY.												
Grasses	55·49	89·89	84·18	72·48	2402·4	3021·9	3782·1	3070·9	+ 219·2	+1899·1	+2100·1	+1406·1
Leguminosæ	5·01	2·37	1·99	3·82	217·0	133·5	89·6	146·7	+ 58·7	− 14·1	− 113·3	− 29·2
Other Orders	39·53	15·63	13·83	23·00	1712·4	584·6	622·3	973·1	+ 742·1	+ 217·0	+ 142·2	+ 367·1
Total	100·00	100·00	100·00	100·00	4332	3740	4500	4190	+1000	+2006	+2130	+1744

The first separation was in the third year of the experiment, when 40 species were found in the sample, there being in that year in the sample from the unmanured plot (3) six fewer than the average, namely, only 43. In the second separation-year (1872) there were 44 species in the sample from plot 18, and 49 in that from plot 3. In the third year, or the thirteenth of the experiment, there were only 39 in the sample from plot 18, but 52 in that from plot 3. There was thus a deficiency in the number of species on the manured plot compared with the unmanured, in the first separation-year of three, in the second of five, and in the third of 13. This, as the actual number of species in each separation-year shows, does not represent anything like a corresponding decline in the actual number of species on the manured plot; the difference between the number on it and that on the unmanured plot being, in fact, due to a considerable increase in the later years in the number on the unmanured, doubtless owing to the decreasing intensity of the struggle without any manure. The increase thus resulting was especially among the Miscellaneæ; of which there were in the samples from the unmanured produce 24 in the first, 28 in the second, and 31 in the third, of the three separation-years; whilst in those from plot 18, the numbers ranged 21, 22, and 21; that is practically showing no change. Upon the whole, then, with somewhat intensified struggle on the manured plot, there are fewer species than without manure; though, with the competition comparatively limited, there is fluctuation according to season, rather than any marked diminution, from one separation-year to another, in the actual number of species coming into the samples.

It will be observed that, with comparatively limited manuring, the nitrogen supplied as ammonia-salts, and comparatively limited luxuriance and struggle, there were only nine grasses which yielded more than 1 per cent. to the produce in one or other of the separation-years. With the less intensity of struggle without manure, there were, however, 12; and on plot 16, with more nitrogen and more mineral matter supplied, but the nitrogen applied as nitrate of soda, and with much more active luxuriance than on plot 18 with the ammonia-salts, there were, nevertheless, 11. This is, no doubt, explained by the fact frequently before referred to, that the nitrogen of ammonia-salts distributes much less rapidly and freely than that of nitrate of soda; and, therefore, even with less luxuriance, and consequently less active competition, the growth of a more limited number is favoured.

The percentage of grasses in the total produce, nevertheless, increased considerably from one separation-year to another. The increase was, however, almost exclusively due to the increased proportion of the poor and comparatively surface-rooting *Festuca ovina*, *Agrostis vulgaris*, *Holcus lanatus*, and *Anthoxanthum odoratum*; which collectively contributed in 1867, 32; in 1872, 60; and in 1877, 67 per cent. to the total herbage. Besides these, *Lolium perenne*, *Avena flavescens* and *pubescens*, *Poa trivialis*, and *Dactylis glomerata*, contributed comparatively small but fluctuating amounts, without very obvious tendency either to increase or to decrease; though *Poa trivialis*, *Avena pubescens*, and *Dactylis glomerata*, showed the greater tendency to decrease.

On the other hand, both the Leguminosæ and the Miscellaneæ diminished in percentage from one separation-year to another.

Among the Leguminosæ, there was a slight tendency to increase in the proportion of *Lathyrus pratensis;* but there was a considerable decrease in that of *Trifolium pratense*, and some in that of *T. repens*, and *Lotus corniculatus*.

Among the six Miscellaneæ which contributed 1 per cent. to the produce in one or other separation-year, *Rumex Acetosa*, *Ranunculus repens* and *bulbosus*, *Plantago lanceolata*, and *Luzula campestris*, markedly declined from the first to the third of the three separation-years; whilst *Achillea Millefolium* showed some tendency to increase, and *Conopodium denudatum* but little either to increase or decrease. Among these, *Rumex Acetosa* was in very abnormally high amount in the first of the three separation-years (1867), in which it will be remembered there was a very large quantity of miscellaneous herbage on most plots. The *Rumex* continued, however, to maintain the first place, *Conopodium denudatum* and *Ranunculus repens* and *bulbosus* also remaining prominent.

The columns of actual yield per acre also show an increase in that of the Graminеæ, and a diminution in that of both Leguminosæ and Miscellaneæ.

Comparing the actual yield per acre of the different species and groups on plot 18 with that on plot 3, without manure, there is (with two exceptions in the first year) an increased yield of every grass in each of the three separation-years under the influence of the manure. The increase in the actual yield of the grasses collectively was very great from one separation-year to another, and it was much the greatest in the case of the poorer and superficially-rooting grasses already referred to, viz.: *Festuca ovina*, *Agrostis vulgaris*, *Holcus lanatus*, and *Anthoxanthum odoratum*.

Of Leguminosæ, there was on the manured plot less actual yield of the two *Trifoliums;* the most marked decline was in the deeply-rooting *Lotus corniculatus;* and there was a uniform but slight increase in the more superficially-feeding *Lathyrus* only. Confining attention to the two later separation-years, when the characteristics of the plot had become the more established, it is seen that there was, with the manure, a greater actual yield of *Rumex Acetosa*, *Conopodium denudatum*, *Ranunculus repens* and *bulbosus*, and *Achillea Millefolium;* but there was a decrease compared with the produce without manure, of *Plantago lanceolata* and *Luzula campestris*, two frequently very persistent elements on permanent grass land under poor conditions.

Upon the whole, it is evident that, with this mixed manure containing the different constituents approximately in the proportion in which they occur in the crop to be grown, with the supply of nitrogen limited, and in the form of ammonia-salts, the effect was by no means equally to favour the increased growth of the groups or species as they were found in the mixed herbage. The effect was, on the other hand, especially to favour the grasses, which came to be very prominent, and particularly the poorer and more superficially-rooting species, which are the most predominant under poor conditions, and which are reputed to be of inferior quality. Further, the amount of leguminous herbage grown on a given area was actually reduced; whilst that of

some of the weeds was notably increased, and of these, that of *Rumex Acetosa* was the most prominently so.

Referring to what has been stated to be one of the main objects of the experiment—to determine whether the mineral constituents, and the nitrogen, contained in one ton of hay would yield one ton of increase, it has been stated generally that only about three-quarters of a ton instead of one ton of increase has been obtained. This is almost precisely the amount reached over the average of the 16 years of the experiment. Over the first 10 years, however, the increase amounted to an average of only half a ton; but during the succeeding six years, in five of which second crops were removed, it was much higher, giving the average of three-quarters of a ton increase for the whole period, as above stated. It is obvious that, with an excess of manure on the manured plot, the exhaustion by the removal of the second crops will be much less on it than on the unmanured plot; and hence the amount of the produce calculated as increase over that without manure will be the greater. There was also a considerably increased yield of both mineral matter and nitrogen over the later as compared with the earlier years, due to the removal of second crops. Still, there was, over the whole period, scarcely more than half of the supplied nitrogen estimated to be recovered; and even over the last six years, in five of which second crops were removed, there was, so far as can be estimated, only about two-thirds of the annually supplied nitrogen annually recovered. In fact, when, as is now done, the results of five more years, in four of which second crops were removed, are brought into the calculation, the general conclusions as stated in Part I., where the points under discussion, and the explanation of the facts, are more fully considered, than would be appropriate here, are not invalidated.

Finally, as will be judged from the results of the separations which have been considered, the general aspect of this plot was not widely different from that of the unmanured plots; but it exhibited a greater preponderance of grasses, and some increased depth of colour, and luxuriance. The appearance of the herbage was, nevertheless, upon the whole, that of restricted growth.

17. *Farmyard manure, alone, and with ammonia-salts in addition; Plots* 2 *and* 1.

We now turn from the consideration of the effects, on the botany of the plots, of more or less complex artificial mixtures of the various constituents of manure, to those of the very complex and heterogeneous natural manure, farmyard dung. To plot 2, farmyard manure, at the rate of 14 tons per acre per annum, was applied for eight consecutive years, from 1856 to 1863 inclusive. To plot 1, the same amount of farmyard manure was annually applied over the same eight years, but with 200 lbs. of ammonia-salts (supplying about 43 lbs. of nitrogen) per acre per annum, in addition. After the eight years, the application of dung was discontinued on both plots; plot 2 remained from that time entirely unmanured; plot 1, however, still received the same annual application of ammonia-salts as previously.

Calculation showed that a comparatively insignificant proportion of both the nitrogen and the mineral constituents estimated to be annually supplied in the dung was annually recovered in the increase of crop yielded; nor did the addition of the ammonia-salts increase the produce so much as might have been expected. It seemed desirable, therefore, to attempt to determine the degree, and the permanence, of the effect of the large amounts of the nitrogen, and of the mineral constituents of the manure, which were calculated not to be recovered in the increase of crop during the years of the application, the greater part of which, at any rate, must be supposed to exist as residue within the soil. Further, so far as there would be a relatively greater available residue of mineral constituents than of nitrogen, it was to be supposed that the application of the ammonia-salts would greatly accelerate the recovery of them.

The main facts relating to the produce and the increase of the total mixed herbage over the first 20 years were considered in detail in Part I.; some reference was also there made to the amounts of the nitrogen, and of the mineral constituents, taken up, and these points will be more fully treated in Part III. It is, however, necessary in order to render intelligible the conditions under which the botanical changes have taken place, that the general results as to the produce, and some of its constituents, should be briefly stated here; and we are now able to give them for 25 years, in five out of the last six of which second as well as first crops were removed, the tendency to exhaustion being thereby considerably accelerated.

Whether we look to the period of the application of the farmyard manure, or to the succeeding periods of six, six, and five subsequent years of the action of the residue, there is a considerable increase compared with the unmanured plot; and there is further increase over each period by the action of the ammonia-salts. There was, however, on all three plots, a considerable reduction in produce during the second six as compared with the first six years after the cessation of the application of the dung on plots 2 and 1. Over the last five years, however, there was a slight excess of produce compared with that over the previous six, even reckoning the first crops only, and, including the second crops, there was a very considerably greater total produce, both on the unmanured and on the manured plots, than over the preceding six years; and over the whole period of 25 years, there was nearly as much annual excess on the manured plots compared with the unmanured, as over the first 20 years.

Much the same may be said of both the total mineral matter and the nitrogen taken up. Indeed, much more of the mineral matter has been annually removed in the first crops only, over the last five years, than over the preceding six, and including the second crops, very much more; in fact, annually more than over the first 20 years. Of nitrogen there was, including the first and second crops, more than one-third more annually taken off without manure, more on plot 2 with dung or its residue alone, and one-third more on plot 1 with the ammonia-salts in addition, over the last five, than over the preceding 20 years. It is obvious, therefore, that the removal of the second crops in the later years is, as before said, rapidly accelerating exhaustion, a fact which

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TABLE LXXXII.—Number of Species, Percentage, Quantity per Acre, &c., of each Species, by Farmyard Manure, alone, Plot 2; and by Farmyard Manure and Ammonia-salts, Plot 1.
(The Farmyard Manure on both Plots the first 8 years only, 1856–63; Plot 2 afterwards unmanured, Plot 1 Ammonia-salts every year.)

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	Number of Species, and proportion per cent.										Quantity per Acre.										Increase + or Decrease − compared with Plot 3.										Increase + or Decrease − compared with Plot 2.					
	Plot 2.					Plot 1.					Plot 2.					Plot 1.					Plot 2.					Plot 1.					Plot 1.						
	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.	1862.	1867.	1872.	1877.	Mean.		
NUMBER OF SPECIES.																																						
Gramineæ	14	17	18	18	17	15	15	16	15	16	...	...	...	...	...	...	...	...	...	...	− 4	+2	+1	+1	0	− 3	0	+ 1	− 2	− 1	+1	− 2	0	− 3	− 1	Gramineæ.
Leguminosæ	3	4	4	4	4	4	4	3	2	3	...	...	...	...	...	...	...	...	...	...	− 1	0	0	0	0	0	0	− 1	− 2	− 1	+1	0	− 1	− 2	− 1	Leguminosæ.
Other Orders	13	20	25	30	22	9	15	15	17	14	...	...	...	...	...	...	...	...	...	...	−15	−4	−3	−1	−6	−19	−9	−13	−14	−14	−4	−5	−10	−12	− 8	Other Orders.
Total	30	41	47	52	43	28	34	36	34	33	...	...	...	...	...	...	...	...	...	...	−20	−2	−2	0	−6	−22	−9	−13	−18	−16	−2	−7	−11	−18	−10	Total.
GRAMINEÆ.																																						
Anthoxanthum odoratum	p. c. 0·20	p. c. 2·86	p. c. 6·67	p. c. 7·20	p. c. 4·23	p. c. 0·07	p. c. 1·35	p. c. 5·78	p. c. 13·88	p. c. 5·27	lbs. 10·1	lbs. 162·5	lbs. 189·9	lbs. 260·1	lbs. 155·6	lbs. 2·9	lbs. 79·4	lbs. 204·1	lbs. 656·8	lbs. 236·1	lbs. − 120·8	lbs. − 123·0	lbs. + 103·2	lbs. + 139·1	lbs. − 0·8	lbs. − 126·7	lbs. − 209·1	lbs. + 118·6	lbs. + 535·8	lbs. + 79·7	lbs. − 6·2	lbs. − 94·1	lbs. + 15·3	lbs. + 396·7	lbs. + 80·5	Anthoxanthum odoratum.
Alopecurus pratensis	3·07	2·48	8·61	9·46	3·65	0·26	1·35	2·93	2·32	1·81	155·3	141·9	158·8	125·0	145·2	14·4	91·1	103·4	119·2	82·0	+ 18·3	− 52·1	+ 150·3	+ 117·9	+ 58·6	− 122·6	− 102·8	+ 94·9	+ 112·1	− 4·6	− 140·9	− 30·7	− 58·4	− 5·9	− 63·2	Alopecurus pratensis.
Agrostis vulgaris	2·84	4·24	11·92	17·97	9·14	0·59	0·45	20·77	22·83	12·83	133·6	297·4	312·0	649·1	344·3	32·6	373·3	738·4	1113·4	564·8	− 213·1	− 5·1	+ 46·7	+ 332·2	+ 40·3	− 313·9	+ 91·9	+ 460·1	+ 799·5	+ 261·4	− 100·8	+ 86·9	+ 421·4	+ 484·3	+ 230·5	Agrostis vulgaris.
Holcus lanatus	1·94	10·94	9·85	11·36	7·77	3·88	10·70	14·06	17·35	11·50	98·2	622·3	193·9	410·3	331·9	215·6	629·2	490·4	821·0	540·6	− 58·6	+ 359·3	+ 134·7	+ 112·6	+ 139·1	+ 61·8	+ 363·7	+ 437·2	+ 824·3	+ 346·8	+ 117·4	+ 3·9	+ 302·5	+ 410·7	+ 208·7	Holcus lanatus.
Avena elatior	2·04	0·40	0·32	0·15	0·78	0·62	0·64	1·62	1·63	1·13	103·2	22·9	14·7	9·4	30·6	34·4	33·6	57·2	78·1	51·3	+ 101·1	+ 18·9	+ 12·6	+ 2·2	+ 23·5	+ 32·3	+ 29·6	+ 55·1	+ 76·9	+ 46·2	− 69·8	+ 12·7	+ 42·3	+ 72·7	+ 14·7	Avena elatior.
Avena pubescens	2·56	3·32	10·26	7·68	6·11	0·55	1·56	2·76	2·66	1·73	[1]79·5	254·6	291·0	277·4	250·6	27·9	92·9	97·4	90·4	79·1	+ 165·0	+ 122·3	+ 232·6	+ 213·8	+ 100·9	− 206·7	− 9·4	+ 30·0	+ 34·9	− 50·6	− 101·7	− 131·7	− 193·6	− 179·0	− 151·5	Avena pubescens.
Avena flavescens	0·02	5·98	11·61	2·92	6·61	2·99	6·85	6·23	1·37	4·61	304·6	338·1	329·0	105·5	26·8	221·7	402·8	220·0	64·8	227·3	+ 232·2	+ 274·1	+ 271·6	+ 80·0	+ 214·3	+ 140·3	+ 340·8	+ 162·6	+ 39·3	+ 173·0	− 82·9	+ 68·7	− 100·0	− 40·7	− 41·5	Avena flavescens.
Poa pratensis	1·66	3·16	2·25	1·20	2·17	1·45	0·56	7·41	1·39	4·29	84·0	203·5	63·7	43·3	98·6	80·6	367·7	261·6	65·3	198·6	+ 75·1	+ 197·8	+ 62·2	+ 41·6	+ 94·2	+ 71·7	+ 332·0	+ 260·1	+ 63·6	+ 194·4	− 3·4	+ 184·3	+ 197·9	+ 22·6	+ 100·2	Poa pratensis.
Poa trivialis	29·16	15·75	3·67	2·37	12·24	31·90	22·26	4·35	2·71	15·32	1423·9	900·8	90·9	55·6	624·7	1772·4	1312·4	153·6	128·2	841·7	+1378·9	+ 801·3	+ 79·7	+ 7·4	+ 567·4	+1720·4	+1273·4	+ 143·4	+ 115·0	+ 814·8	+ 348·5	+412·1	+ 89·7	+ 42·6	+217·0	Poa trivialis.
Dactylis glomerata	4·51	6·51	3·27	2·79	4·27	16·43	6·43	3·91	4·23	7·60	228·2	372·1	92·6	100·7	198·4	912·9	878·1	116·9	200·2	402·0	+ 174·5	+ 314·1	+ 77·8	+ 84·1	+ 167·6	+ 859·2	+ 820·1	+ 102·1	+ 183·6	+ 366·2	+ 6·4·7	+ 6·0	+ 24·3	+ 99·5	+203·6	Dactylis glomerata.
Festuca ovina	0·37	4·59	9·99	11·23	6·32	0·76	0·17	6·40	10·75	6·02	18·7	262·4	260·0	406·6	241·7	42·2	362·8	226·0	508·7	284·9	− 387·2	− 244·1	− 76·2	− 111·9	− 204·8	− 363·7	− 143·7	− 130·2	− 8·8	− 161·6	+ 23·5	+100·4	− 54·0	+ 103·1	+ 43·2	Festuca ovina.
Bromus mollis	17·77	10·39	2·98	0·18	9·56	21·91	10·55	4·55	0·83	9·46	[2]997·2	586·2	110·1	6·5	450·1	1217·8	626·3	160·7	39·3	509·8	+ 630·2	+ 325·1	+ 109·9	+ 6·5	+ 468·6	+1213·9	+ 618·6	+ 160·5	+ 32·3	+ 509·0	+ 343·5	−316·6	+ 50·6	+ 32·8	+ 21·4	Bromus mollis.
Lolium perenne	1·43	3·63	3·17	4·92	3·29	1·42	3·19	1·71	1·66	1·99	72·4	207·5	89·8	177·7	136·6	76·9	187·6	60·4	78·6	101·4	− 122·0	+ 73·2	+ 50·8	+ 70·1	+ 18·0	− 115·5	+ 53·3	+ 21·4	− 29·0	− 17·4	+ 6·5	− 19·9	− 29·4	− 99·1	− 35·4	Lolium perenne.
None yielding 1 per cent. — Phleum pratense, Aira caspitosa, Briza media, Cynosurus cristatus, Festuca pratensis	0·01	0·37	1·04	1·99	0·86	0·11	0·10	0·11	0·02	0·10	0·5	21·1	29·4	72·0	30·6	0·1	5·9	4·0	1·0	4·2	− 64·2	− 5·9	− 94·4	− 122·7	− 72·0	− 59·6	− 21·1	− 119·6	− 194·7	− 98·6	+ 5·6	− 15·2	− 25·4	− 10·2	− 26·6	None yielding 1 per cent. — Phleum pratense, Aira caspitosa, Briza media, Cynosurus cristatus, Festuca pratensis.
Absent—Festuca hilaeca	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	− 0·7	− 0·2	...	...	...	...	...	...	...	...	...	Absent—Festuca hilaeca.
Undetermined (chiefly Gramineæ)	2·65	2·29	0·87	...	1·45	5·07	1·99	0·22	...	1·82	134·1	130·6	24·6	...	72·4	281·6	117·0	7·7	...	101·6	— 105·2	— 73·7	— 24·1	...	— 50·7	+ 42·3	− 87·5	− 41·0	...	− 21·5	+ 147·5	− 13·9	− 16·9	...	+ 29·2	Undetermined (chiefly Gramineæ).
Total	75·05	84·32	80·02	75·42	78·75	88·97	86·43	82·21	83·96	85·39	3797·5	4831·1	2265·3	2734·2	3404·5	4943·1	5092·1	2902·8	3973·0	4223·3	+1642·8	+2647·7	+1136·5	+1042·2	+1617·2	+2788·1	+2898·7	+1774·0	+2291·0	+2438·0	+1145·6	+251·0	+637·5	+1248·8	+820·8	Total.
LEGUMINOSÆ.																																						
Trifolium repens	0·60	0·86	0·82	0·16	0·34	0·03	0·07	0·01	0·01	0·03	30·4	3·4	14·7	5·8	13·6	1·7	4·1	0·4	0·5	1·7	+ 14·2	− 3·6	+ 8·5	+ 2·7	+ 5·5	− 14·8	− 2·9	− 5·8	− 2·6	− 6·4	− 28·7	+ 0·7	− 14·3	− 5·3	− 11·9	Trifolium repens.
Trifolium pratense	0·34	0·20	0·25	0·96	0·47	0·03	0·06	0·01	...	0·03	17·2	17·2	7·3	34·7	19·1	1·7	1·7	0·4	...	0·3	− 13·2	− 3·1	− 19·7	+ 14·7	+ 5·3	− 67·4	− 27·2	− 49·4	− 69·7	− 15·5	− 14·3	− 7·5	− 34·7	− 17·1	Trifolium pratense.
Lotus corniculatus	...	0·10	0·17	0·17	0·11	0·01	0·01	...	...	0·01	...	3·7	4·8	0·1	4·2	0·6	0·6	...	...	0·3	− 55·9	− 72·6	− 92·9	− 87·3	− 77·1	− 55·3	− 77·7	− 97·7	− 93·4	− 81·0	+ 0·6	− 5·1	− 4·8	− 6·1	− 3·9	Lotus corniculatus.
Lathyrus pratensis	0·98	1·17	3·06	3·23	2·84	0·12	0·88	0·32	0·56	0·47	49·6	66·9	112·2	189·6	104·6	0·6	5·0	1·2	2·6	22·8	+ 11·2	+ 44·2	+ 96·1	+ 133·6	+ 71·3	− 31·8	+ 27·3	− 4·9	− 32·4	− 10·5	− 43·0	− 16·9	− 101·0	− 166·0	− 81·9	Lathyrus pratensis.
Total	1·92	1·63	4·93	4·54	3·76	0·19	0·98	0·34	0·51	0·51	97·2	93·2	139·6	230·2	141·6	10·6	57·6	12·0	24·1	26·1	− 150·0	− 85·1	− 8·0	+ 34·3	− 52·1	− 236·6	− 120·7	− 135·6	− 177·8	− 167·6	− 86·6	− 35·6	− 127·6	− 212·1	− 115·5	Total.
OTHER ORDERS.																																						
Ranunculus acris	...	0·02	1·02	1·49	0·63	...	0·26	0·14	1·30	0·42	...	1·1	29·2	53·9	20·9	...	16·3	4·9	61·5	20·4	− 0·3	+ 0·8	+ 27·7	+ 53·8	+ 20·4	− 0·3	+ 15·0	+ 3·7	+ 61·5	+ 19·9	...	+ 14·2	− 24·0	+ 7·7	− 0·5	Ranunculus acris.
Ranunculus repens et bulbosus	2·49	0·99	1·33	3·58	2·34	1·53	0·37	0·56	1·28	0·94	146·2	56·6	42·3	129·3	93·6	65·0	21·8	20·4	60·6	46·9	− 2·7	− 10·4	− 8·0	+ 47·7	+ 7·4	− 63·9	− 45·2	− 27·9	− 21·0	− 39·5	− 61·2	− 34·9	− 22·9	− 69·7	− 46·9	Ranunculus repens et bulbosus.
Cerastium triviale	0·01	0·55	1·72	0·40	0·42	...	0·11	0·24	0·47	0·20	0·5	2·9	34·5	14·4	13·1	...	0·5	0·4	22·2	9·3	− 13·6	− 9·3	+ 20·5	− 5·0	− 1·8	− 14·1	− 5·7	− 5·6	+ 2·8	− 6·6	− 0·5	+ 2·6	+ 26·1	+ 7·8	− 3·8	Cerastium triviale.
Compositum dandatum	2·93	2·48	1·15	0·96	1·94	1·46	1·99	0·55	0·56	1·04	147·2	182·9	32·6	24·7	96·3	61·1	93·5	19·4	26·5	50·1	+ 113·6	+ 64·6	− 14·2	− 10·2	+ 38·4	+ 51·5	− 4·8	− 27·4	− 12·4	+ 0·2	− 62·1	− 69·4	− 12·2	− 9·2	− 38·2	Compositum dandatum.
Centaurea nigra	0·04	0·14	1·26	0·90	0·59	...	0·18	1·24	0·25	0·41	2·0	8·0	36·2	32·5	19·7	...	10·0	43·8	11·8	16·6	− 7·5	− 11·7	+ 1·6	+ 7·4	− 2·5	− 9·5	− 9·1	+ 9·2	+ 13·3	− 5·6	− 2·0	+ 2·6	+ 7·6	− 20·7	− 3·1	Centaurea nigra.
Achillea Millefolium	2·41	1·09	2·93	2·17	2·15	1·35	3·07	5·01	0·72	2·54	122·0	62·3	82·9	78·4	86·4	75·0	180·4	177·0	34·1	116·6	+ 75·3	+ 23·6	+ 53·6	+ 31·4	+ 46·0	+ 29·3	+ 141·7	+ 147·7	+ 12·9	+ 70·2	− 47·0	+118·1	+ 94·1	− 44·3	+ 30·2	Achillea Millefolium.
Plantago lanceolata	1·67	2·08	1·45	3·70	2·47	0·30	0·51	0·14	0·27	0·30	84·5	174·1	41·0	132·6	108·8	16·7	30·0	4·9	12·9	16·1	− 139·5	− 181·4	− 27·7	+ 58·9	− 66·2	− 207·3	− 227·5	− 38·9	− 61·9	− 159·9	− 67·6	− 146·1	− 36·1	− 120·6	− 92·7	Plantago lanceolata.
Veronica Chamædrys	0·28	1·66	1·25	0·72	0·98	...	0·28	0·03	0·01	0·08	14·2	94·9	35·4	30·0	42·6	...	16·5	1·1	0·5	4·5	− 0·5	+ 84·2	+ 33·1	+ 20·3	+ 24·2	− 14·7	+ 5·8	− 1·2	− 5·2	− 3·9	− 14·2	− 78·4	− 34·3	− 25·5	− 38·1	Veronica Chamædrys.
Rumex Acetosa	12·44	3·07	1·93	2·46	4·97	6·09	5·74	9·29	10·49	7·90	629·5	173·5	54·6	88·9	237·1	338·4	327·4	329·0	496·4	375·1	+ 588·8	+ 116·8	+ 25·5	+ 44·7	+ 193·4	+ 295·7	+ 278·7	+ 298·9	+ 452·2	+ 331·4	− 291·1	+ 161·9	+ 273·4	+ 407·5	+ 138·0	Rumex Acetosa.
None yielding 1 per cent. — Stellaria graminea, Potentilla reptans, Agrimonia Eupatoria, Spiræa Ulmaria, Pimpinella Saxifraga, Heracleum Sphondylium, Anthriscus sylvestris, Galium verum, Scabiosa arvensis, Bellis perennis, Tragopogon pratensis, Leontodon hispidus, Taraxacum officinale, Prunella vulgaris, Ajuga reptans, Primula veris, Scilla nutans, Luzula campestris, Carex præcox, Hypnum squarrosum, H. blanc, H. rutabulum	0·46	0·90	1·29	1·06	1·10	0·11	0·48	0·23	0·18	0·27	23·2	51·4	36·7	60·0	43·0	0·1	29·3	9·3	8·5	12·8	− 95·5	− 248·5	− 73·2	− 50·8	− 116·8	− 100·5	− 247·0	− 78·9	− 63·7	− 124·0	− 17·1	− 23·1	− 28·4	− 51·5	− 30·2	None yielding 1 per cent. — Stellaria graminea, Potentilla reptana, Agrimonia Eupatoria, Spiræa Ulmaria, Pimpinella Saxifraga, Heracleum Sphondylium, Anthriscus sylvestris, Galium verum, Scabiosa arvensis, Bellis perennis, Tragopogon pratensis, Leontodon hispidus, Taraxacum officinale, Prunella vulgaris, Ajuga reptans, Primula veris, Scilla nutans, Luzula campestris, Carex præcox, Hypnum squarrosum, H. blanc, H. rutabulum.
Absent — Poterium Sanguisorba, Galium Aparine, Chrysanthemum Leucanthemum, Hieracium Pilosella, Thymus Serpyllum, Ophioglossum vulgatum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	− 0·6	− 7·3	− 8·4	− 26·7	− 10·8	− 6·7	− 31·9	− 31·2	− 65·3	− 33·8	...	...	...	...	...	Absent. — Poterium Sanguisorba, Galium Aparine, Chrysanthemum Leucanthemum, Hieracium Pilosella, Thymus Serpyllum, Ophioglossum vulgatum.
Total	23·03	12·85	15·05	16·04	17·49	10·84	12·39	17·45	15·53	14·10	1168·3	791·7	426·1	651·6	758·7	602·3	740·3	616·2	734·9	673·4	+ 515·5	− 178·6	+ 58·5	+ 171·5	+ 141·7	− 47·5	− 230·0	+ 248·6	+ 254·9	+ 56·4	− 563·0	− 51·4	+190·1	+ 83·3	− 85·3	Total.
SUMMARY.																																						
Gramineæ	75·05	84·32	80·02	75·42	78·75	88·97	86·43	82·21	83·96	85·39	3797·5	4831·1	2265·3	2734·2	3404·5	4943·1	5092·1	2902·8	3973·0	4225·3	+1642·8	+2647·7	+1136·5	+1042·2	+1617·2	+2788·1	+2898·7	+1774·0	+2291·0	+2438·0	+1145·6	+251·0	+637·5	+1248·8	+820·8	Gramineæ.
Leguminosæ	1·92	1·63	4·93	4·54	3·76	0·19	0·98	0·34	0·51	0·51	97·2	93·2	139·6	230·2	141·6	10·6	57·6	12·0	24·1	26·1	− 150·0	− 85·1	− 8·0	+ 34·3	− 52·1	− 236·6	− 120·7	− 135·6	− 177·8	− 167·6	− 86·6	− 35·6	− 127·6	− 212·1	− 115·5	Leguminosæ.
Other Order	23·03	12·85	15·05	16·04	17·49	10·84	12·39	17·45	15·53	14·10	1168·3	791·7	426·1	651·6	758·7	602·3	740·3	616·2	734·9	673·4	+ 515·5	− 178·6	+ 58·5	+ 171·5	+ 141·7	− 47·5	− 230·0	+ 248·6	+ 254·9	+ 56·4	− 563·0	− 51·4	+190·1	+ 83·3	− 85·3	Other Orders.
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	5080	5716	2831	3612	4304	5556	5890	3531	4732	4924	+2008	+2384	+1187	+1248	+1706	+2504	+2548	+1987	+2388	+2326	+ 496	+ 164	+700	+1120	+620	Total.

should have a marked influence on the relative proportion, and the degree of luxuriance, of the various components of the mixed herbage.

The folding Table (LXXXII.) gives the percentage and per acre results of the four complete botanical separations, of the produce of plot 2 with dung alone, or its residue, and of that of plot 1 with ammonia-salts in addition. It also gives the increase in actual yield of each species or group over that on plot 3 without manure, and the increase on plot 1, with the ammonia-salts, over plot 2 without them.

The first separation-year (1862) was the seventh, and the last but one, of the application of the dung, so that the botanical condition of the plots at that period best represents the direct effects of the manure. The subsequent results on plot 2 show the effects of the discontinuance of the manure, and the gradual approximation to the unmanured condition. The results for plot 1 show the modifications induced during, or after the cessation of the application of dung, when ammonia-salts were also applied.

It will be observed that, in the first separation-year, the number of species was very much lower on the manured plots than on the unmanured one; and it was lower with the greater luxuriance, and the consequent more active struggle, where the ammonia-salts were applied.

After the cessation of the application of the dung, the number of species increased on both plots; but very much more without than with the ammonia-salts. Thus, the numbers were, in the four separation-years, on plot 2—30, 41, 47, and 52, and on plot 1, with the ammonia-salts, 28, 34, 36, and 34. In fact, under the influence of the residue of the dung alone the number of species rapidly increased, and finally reached that without manure; whilst, with the ammonia-salts in addition, the increase was comparatively very slight, and in the last separation-year there were 18 fewer species than without manure, or with the residue of the dung on plot 2. The reduction in the number, under the influence both of the direct application of the dung, and of that of the ammonia-salts, was almost exclusively in miscellaneous species; and the great relative deficiency of these in the later years, where the ammonia was supplied, is a striking illustration of the effects of increasing the luxuriance of the grasses in displacing their competitors.

We have thus far given an outline of the differences between the amounts of produce, the yield of some constituents, and the general botanical character of the herbage, on the two farmyard-manured plots as compared with the unmanured plot. In considering the botanical results in more detail, it will conduce to clearness to confine attention in the first place to the actual and comparative results on plot 2, with the dung or its residue, and afterwards to trace separately the effects of the addition of the ammonia-salts.

A glance at the table shows that, in 1862, the dung being still annually applied, there was a smaller percentage both of total Graminea, and of total Leguminosæ, and,

notwithstanding the reduced number of miscellaneous species, a higher percentage of total miscellaneous herbage, than after the discontinuance of the dung.

In that, the first separation-year, by far the most prominent grasses were *Poa trivialis* and *Bromus mollis*, both of which had declined to a comparatively insignificant amount by the fourth separation-year. *Avena flavescens* and *Dactylis glomerata* were the next in order of prominence in the first year, and, though each afterwards fluctuated in amount, each yielded less in the fourth than in the first separation-year. The other grasses that yielded appreciable but comparatively small quantities were *Alopecurus pratensis*, *Agrostis vulgaris*, *Avena pubescens*, *Avena elatior*, *Holcus lanatus*, *Poa pratensis*, and *Lolium perenne*. Of these, after the cessation of the application of the dung, that is, as the plot gradually approached the unmanured condition, *Agrostis vulgaris*, *Holcus lanatus*, and *Avena pubescens* increased very largely. *Festuca ovina* also gradually increased from a fraction of 1 per cent. in the first to more than 11 per cent. in the fourth separation year, *Anthoxanthum odoratum* from a small fraction of 1 per cent. to more than 7 per cent., and *Lolium perenne* from less than 1½ per cent. to nearly 5 per cent. *Alopecurus* also, upon the whole, somewhat increased. But, besides *Poa trivialis* and *Bromus mollis*, which were so prominent at first but which decreased so strikingly, *Avena elatior* and *Poa pratensis*, at all times in small amount, also showed a tendency to diminish.

Thus, whilst *Poa trivialis*, *Bromus mollis*, *Avena flavescens*, and *Dactylis glomerata*, had been brought into greater or less prominence under the influence of the dung, the prevailing grasses of the locality under poor condition—*Festuca ovina*, *Agrostis vulgaris*, *Holcus lanatus*, and *Anthoxanthum odoratum*—were discouraged. But, on the cessation of the application of the dung, and the gradual assimilation to the unmanured condition, the certainly better grasses which had been previously encouraged were now discouraged, and the inferior ones which had previously been discouraged were now encouraged.

The table shows a much less percentage, and also actual amount, of leguminous herbage in the first year than after the cessation of the dung. The percentage increased from under 2 in the first to more than 6½ in the fourth separation-year; and the actual amount from under 100 lbs. per acre in the first to 236 lbs. in the fourth separation-year. The increase was almost exclusively of *Lathyrus pratensis;* but there was a tendency to increase rather than to decrease in *Trifolium pratense* also.

Of miscellaneous species, a much larger number than is usual on the manured plots comes into the list of those which have yielded more than 1 per cent. to the produce in one or other separation-year. There were in the first year only five, but taking together the three subsequent separation-years there have been nine in this category. In the first year, that is, under the immediate influence of the application of the dung, *Rumex Acetosa* was not only in very large amount, but it even contributed more than half the total miscellaneous herbage. *Ranunculus repens* and *bulbosus*, *Conopodium denudatum*, *Achillea Millefolium*, and, in a less degree, *Plantago lanceolata*, were also

fairly prominent. *Veronica Chamædrys*, *Centaurea nigra*, and *Cerastium triviale*, occurred in only insignificant amounts. In the second and subsequent separation-years, notwithstanding that the second (1867) was very favourable to the growth of miscellaneous herbage over the plots generally, the Miscellaneæ collectively, and the *Rumex* especially, were in very much smaller proportion, and amount, than in the first separation-year. Of the other species, those which gained ground, or maintained a fair relative position, after the discontinuance of the dung, were *Plantago lanceolata*, *Ranunculus repens* and *bulbosus*, and *Achillea Millefolium*. *Ranunculus acris*, *Centaurea nigra*, *Veronica Chamædrys*, and *Cerastium triviale*, though in smaller amounts, also showed tendency to increase. *Conopodium denudatum*, on the other hand, gradually diminished. The tendency of change under the influence of the decreasing available residue of the dung was, in fact, to decrease the unusual prominence of *Rumex*, and to bring a larger number of species into position in the struggle.

Comparing the actual yield of the different groups and species of plants on plot 2 with their amounts without manure, it is seen that in the first separation-year there was a very considerable excess of total Graminеæ, a deficiency of total Leguminosæ, and a large excess of total Miscellaneæ, under the influence of the dung. Among the grasses, *Poa trivialis* and *Bromus mollis* were in very large excess. *Avena flavescens*, *Dactylis glomerata*, and *Avena elatior*, were in moderate, and *Poa pratensis* in small excess. On the other hand, those which were in marked deficiency, compared with the produce without manure, were *Festuca ovina*, *Agrostis vulgaris*, *Avena pubescens*, *Lolium perenne*, and *Anthoxanthum odoratum*. It is thus seen that the grasses which yielded an excess on the manured plot were, for the most part, of freer growth and of better repute, whilst those which were in deficiency are characteristic of conditions of limited competition. After the discontinuance of the dung *Poa trivialis* and *Bromus mollis*, which were previously in such large excess, declined to quite insignificant amounts in the fourth year. *Avena flavescens*, *A. elatior*, *Dactylis glomerata*, and *Poa pratensis*, also declined; whilst *Agrostis vulgaris* and *Festuca ovina* increased largely, both in actual amount and in relation to their yield without manure; and *Avena pubescens*, *Anthoxanthum odoratum*, *Holcus lanatus*, *Alopecurus pratensis*, and *Lolium perenne*, did so in a less degree.

Of total Leguminosæ, there was an actual deficiency on the dunged plot compared with the amount without manure; but the deficiency diminished from year to year after the cessation until, in the fourth separation-year, there was even a rather greater actual amount on the plot which had been for the shorter period without manure. In the first year, that is, during the application of the dung, the deficiency was chiefly in *Trifolium pratense*, and, in a less degree, in *Lotus corniculatus*. Subsequently, *Trifolium pratense* gained in relative position, *Lotus corniculatus* lost, *Trifolium repens* changed but little, but *Lathyrus pratensis* considerably increased. Thus it was the comparatively surface-rooting *Lathyrus* that chiefly gained under the influence of the abundant, but only slowly available residue of manurial constituents; and, under

the same conditions, the also surface-rooting *Trifolium repens* fluctuated little. It was under the same conditions that the deeper-rooting *Trifolium pratense* continued, though decreasingly, in relative defect; whilst the also deep-rooting *Lotus corniculatus* showed somewhat greater relative deficiency under the influence of the residue than in the years of the application of the dung.

Comparing the produce of miscellaneous species with the manure with that without it, there was in the first separation-year, as already indicated, a very great excess of *Rumex Acetosa* on the manured plot, and some excess of *Conopodium denudatum* and *Achillea Millefolium* also. The species most markedly in defect under the influence of the manure was *Plantago lanceolata*. The difference in the amounts yielded on the two plots of *Cerastium triviale*, *Centaurea nigra*, *Veronica Chamædrys*, and the several species of *Ranunculus*, was too small to be of any significance. The plants, which remained, or became, in excess over the unmanured yield of them, after the application of the manure was discontinued, were *Rumex Acetosa*, *Achillea Millefolium*, the various species of *Ranunculus*, *Plantago lanceolata*, and *Veronica Chamædrys*, and in an insignificant degree *Centaurea nigra*; whilst *Conopodium denudatum* went down considerably, and *Cerastium triviale* fluctuated above and below the continuously unmanured produce of it. The general result was then, that a larger number maintained a moderate position, and none were so specially prominent, after the discontinuance of the manure—that is, as the activity of the struggle became less and less.

The point last referred to—that is, the decrease in the predominance of a few individual species, and the increase in the number showing moderate prominence, as the unmanured condition was approached—was equally observable in the case of the Graminеæ as in that of the Miscellaneæ. In the case of the Leguminosæ, the stoppage of the manure most prominently favoured the increased growth of the surface-rooting *Lathyrus*, but otherwise only slightly affected the growth of the leguminous plants, both *Trifolium pratense* and *Lotus corniculatus* remaining in obvious deficiency as compared with their produce without manure continuously.

Upon the whole, whether we look to the number of species which came to maintain a moderate position, or to the character of the species which did so, it is obvious that the general result was that of diminishing intensity of competition, and of gradual approach to the conditions on the continuously unmanured plot.

Thus, the tendencies of botanical change, as well as the particulars of produce which have been briefly referred to, concur in showing that, notwithstanding the enormous unrecovered amount of some of the most important constituents supplied in the dung during the first eight years of the experiments, the residue remaining in the soil was, after a few years, in a very slowly available condition, and, so far as it was available, chiefly so to the more superficially-rooting species. Of the nitrogen of the dung estimated to be unrecovered, part, at any rate, would probably remain in a condition very slowly liberated from its existing state of combination, whilst a portion would be subject to loss by drainage. On the other hand, the more important mineral constituents, though

they might be but slowly available, would be little if at all subject to loss by drainage, and would probably remain within a comparatively limited depth from the surface.

We have now to consider whether an annual additional supply of nitrogen in the form of ammonia-salts increased luxuriance, and rendered the comparatively dormant residue of the mineral constituents of the dung more rapidly available, a necessary result of which would be increased intensity of competition. We have also to consider, what has been the effect of the addition on the relative predominance, and the actual yield, of the various species in the mixed herbage, as shown by the botanical separations. To this end we turn to the results in the folding Table LXXXII., facing p. 1407, relating to plot 1, with the ammonia-salts, and to the comparison of them with those of plot 2, without them.

It has been already shown, that one effect of the ammonia-salts was greatly to reduce the number of species, especially of miscellaneous plants. In the first separation-year (1862), the seventh of the application of the dung to plot 2, and the seventh of the application of dung and ammonia-salts together to plot 1, the main distinctions between the two plots were as follows:—

With the ammonia-salts there was a much larger percentage and actual amount of gramineous herbage, very much less leguminous, and also very much less miscellaneous herbage. Referring to individual species, *Poa trivialis* and *Bromus mollis*, which were in very great prominence on plot 2, were in greater prominence still with the ammonia. *Dactylis glomerata* was also in very much larger percentage and amount with than without the ammonia-salts. The only other grasses in any fair amount with the ammonia-salts were *Avena flavescens* and *Holcus lanatus;* whereas, without the ammonia, besides these two, *Alopecurus pratensis, Avena pubescens, A. elatior,* and *Agrostis vulgaris,* were also in fair quantity. In other words, with the ammonia-salts, a few individual grasses attained greater prominence, and the rest were more meagrely represented than without them. We have, in fact, with the ammonia, the constantly observed result of increased vegetative luxuriance.

Leguminous species were, under the influence of the dung and ammonia-salts together, almost banished; *Lathyrus pratensis,* however, retaining the first place.

Of miscellaneous species, there were in 1862 only four on plot 1 with the ammonia-salts which contributed as much as 1 per cent., whilst there were five on plot 2 without them. The percentage of Miscellaneæ was, indeed, less than half, and the actual amount per acre little more than half, as much with as without the ammonia-salts. *Rumex Acetosa* was, on plot 1 as on plot 2, the most prominent, but in only about half the proportion and amount with the ammonia-salts. The other miscellaneous plants of moderate prominence on plot 1 were the same as were so on plot 2, viz.: *Ranunculus repens* and *bulbosus, Conopodium denudatum, Achillea Millefolium,* and *Plantago lanceolata;* but each was in considerably less proportion and amount than on plot 2. The general result on this point is, then, that with the increased luxuriance of a few grasses, there is diminished predominance of other grasses, and of Miscellaneous plants, and a still greater diminution of Leguminosæ.

In the subsequent separation-years—that is, after the discontinuance of the dung on both plots, but with the application of the ammonia-salts continued on plot 1—a marked change in the botany of the plot became apparent. As on plot 2, the two previously most prominent grasses, *Poa trivialis* and *Bromus mollis*, declined rapidly, as also did *Dactylis glomerata*. Again, as on plot 2, but in a much more marked degree, *Agrostis vulgaris* and *Holcus lanatus* rapidly increased; as also, though attaining a somewhat less degree of prominence than the foregoing, did *Anthoxanthum odoratum* and *Festuca ovina*, the *Anthoxanthum* attaining a very exceptional degree of prominence for that plant. Of other species, *Alopecurus pratensis*, *Avena pubescens*, and *A. elatior*, increased in a small degree, whilst *Poa pratensis* and *Lolium perenne* fluctuated. The result was, that a larger number maintained a fair position on the ammonia plot after the cessation of the application of the dung.

Leguminosæ, especially *Lathyrus pratensis*, somewhat increased after the first separation-year, but in too small proportion and amount to be attributed with certainty to the changed condition of manuring.

Of Miscellaneæ, upon the whole, a greater number came into the list of those yielding 1 per cent. to the produce after the change. But, under the influence of the continued supply of ammonia-salts, and the declining effect of the dung-residue, *Rumex Acetosa* increased very considerably, and in each year yielded a large proportion of the total miscellaneous produce; whilst on plot 2, without the ammonia-salts, it greatly diminished. *Achillea Millefolium* also upon the whole increased in prominence, and the various species of *Ranunculus* were somewhat favoured. *Cerastium triviale* and *Centaurea nigra*, although in small proportions, also increased. *Conopodium denudatum*, on the other hand, diminished.

The comparison of the botany of the herbage on plot 1 with the ammonia-salts, with that on plot 2 without them, is shown in the last five columns of the table. It is seen that in the first separation-year, that is before the discontinuance of the farmyard manure, the plot with the ammonia-salts showed a large excess of produce of the grasses collectively, a considerable deficiency in that of the Miscellaneæ, and also a deficiency in that of the Leguminosæ.

The grasses which were the most prominently in excess under the influence of the ammonia-salts were *Dactylis glomerata*, *Poa trivialis*, and *Bromus mollis*. *Holcus lanatus* was so in a less degree, and *Festuca ovina* and *Lolium perenne* less still. The grasses in actual deficiency under the influence of the ammonia-salts, and of the increased luxuriance of the foregoing species, were *Alopecurus pratensis*, *Agrostis vulgaris*, and the three *Avenas—pubescens*, *flavescens*, and *elatior*. Thus, the grasses which were the most prominent were for the most part comparatively free-growing and free-feeding species.

The figures relating to the three subsequent separations show a marked change in the relation of the two plots after the cessation of the application of the farmyard manure. On plot 1, with the ammonia, there comes to be—but little excess of

Dactylis glomerata, *Poa trivialis*, or *Bromus mollis*; a very large excess of *Agrostis vulgaris*, *Holcus lanatus*, and *Anthoxanthum odoratum*, and some of *Festuca ovina*, and *Avena elatior*; and an actual deficiency, compared with plot 2, of two of the *Avenas*, *pubescens* and *flavescens*, and of *Lolium perenne*. That is to say, after the discontinuance of the dung, the greater growth of grasses with, than without, the ammonia-salts is chiefly due to a greater prominence, and a greater luxuriance, of the poorer species, *Agrostis vulgaris*, *Holcus lanatus*, *Anthoxanthum odoratum*, and *Festuca ovina*.

Whilst, without the ammonia-salts, Leguminosæ greatly increased in prominence, with them the quantity remained so small that the deficiency compared with plot 2 increased from year to year, the result being mainly due to the relatively deficient growth of *Lathyrus pratensis*.

Of total Miscellaneæ, with a great relative deficiency on plot 1 in the first separation-year, there was subsequently even a slight excess. This was in fact exclusively due to the very much greater growth of *Rumex Acetosa*. Indeed, almost all the other miscellaneous species show either an average or an increasing relative deficiency with the ammonia-salts; the most marked decline, compared with plot 2, being in *Plantago lanceolata*, *Achillea Millefolium*, and *Ranunculus repens* and *R. bulbosus*. We have then, where the ammonia-salts were applied, a greater prominence of individual miscellaneous species, and especially of *Rumex Acetosa*, as the excess of available nitrogen relatively to the available supply of other constituents became the more marked.

Upon the whole, notwithstanding the large unrecovered residue of the manurial constituents remaining in the soil, the approximation in the botanical composition of the herbage to that without manure is very obvious on plot 2 after the cessation of the application of the dung. It is, however, much less so on plot 1 with the ammonia-salts. It is true that, on both plots, some of the better and freer-growing grasses decline, and poorer and more meagrely-growing ones gain in prominence; but these do so in the main in a much greater degree with the partially forced, but at the same time restricted, growth under the influence of the ammonia-salts. That there was, on plot 1, a supply of available nitrogen in excess of that of the available mineral constituents, was quite obvious from the increased predominance of gramineous herbage, with at the same time dark green leafy growth, and relatively less tendency to mature. Under these circumstances, too—and the nitrogen being supplied in a condition in which it is much more rapidly available than the greater part of that in dung, but less rapidly distributing than in nitrate of soda—it is to be expected that the more superficially rooting species should be the more favoured; especially if they are also such as generally prevail under conditions of little competition with more free-growing species.

DETAILED results of Experiments at Rothamsted, illustrating the Domination of one Plant over and

APPENDIX–TABLE X.—Number of Species, and Percentage of each Species, and of each Group (Gramineæ, Leguminosæ, and Miscellaneæ), in the to

Description of Manure	Without Manure, 1856, and since.				Farmyard Manure, 8 years, 1856–63; discontinued 1864, and since.								Superphosphate of Lime each year, 1850, and since.								Ammonia-salts alone, = 86 lbs. Nitrogen.				"Mixed Mineral Manure"—Sulp																	
					With Ammonia-salts = 43 lbs. Nitrogen.				Alone.				Alone.				With Ammonia-salts = 86 lbs. Nitrogen.								1869 and since; previously (15 years, 1856–69) Ammonia-salts.				Alone, each year, 1856 and since.				With Potass, 6 years, 1856–61; without Potass, 1862 and since.				With Ammonia-salts = 86 lbs. Nitrogen.				Mineral Manures as Plot 9, and Ammonia-salts = 86 lbs. Nitrogen.			
Plot Numbers	3			12	1				2				4-1				4-2				6				7				9				9				10			
Seasons	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1873	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877
GRAMINEOUS HERBAGE.																																								
Number of Species	18	15	17	17	16	16	17	16	15	15	18	15	14	17	18	18	16	15	16	16	14	14	15	13	17	15	15	13	15	14	17	14	18	16	17	17	17	17	16	13	14	16	13	16	15	15	15
Botanical Names:—																																														
1. Anthoxanthum odoratum	4·28	9·66	5·20	5·12	4·09	7·66	6·67	5·47	0·07	1·35	5·78	13·88	0·20	2·86	6·67	7·20	3·66	7·16	4·74	5·11	2·24	5·52	1·47	2·36	5·77	5·51	3·04	4·09	3·92	4·31	6·22	4·89	3·06	2·93	2·73	3·18	3·72	6·99	7·94	7·55	1·24	3·59	2·25	2·94	1·46	5·27	3·26	5·9
2. Alopecurus pratensis	4·49	5·82	0·32	0·30	3·12	2·62	2·74	0·96	0·26	1·55	2·93	2·52	3·07	2·48	5·61	3·46	1·32	1·84	0·86	1·40	0·66	14·75	3·94	1·58	0·65	0·47	0·83	0·23	1·70	0·02	0·03	0·09	0·34	0·88	1·17	0·48	0·39	0·86	0·52	0·87	0·27	0·07	2·78	0·96	2·05	2·99	19·35	16·3
3. Phleum pratense	0·01	...	...	...	0·01	...	...	...	0·09	0·03	0·06	...	...	0·05	0·04	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·04	...	...	...
4. Agrostis vulgaris	11·36	9·63	16·14	13·28	9·43	5·35	11·13	13·29	0·59	0·45	20·77	23·53	2·64	4·94	11·02	17·97	7·21	6·08	13·88	9·37	19·38	14·00	20·50	24·39	24·30	20·97	26·62	22·46	21·43	14·41	23·37	21·98	7·14	4·69	11·72	12·62	10·01	4·32	7·32	12·40	12·91	13·43	15·46	12·23	9·50	8·24	4·37	4·7
5. Alra cæspitosa	0·01	...	0·01	0·04	...	...	0·01	...	...	...	0·01	0·01	...	...	0·01	0·01	...	...	0·04	...	...	...	0·01	0·01	0·01	0·01	...	...	0·01	0·01	0·01	0·01	...	...	...	...	0·01	...	...	...	...	0·01	0·01	...	...	0·1
6. Holcus lanatus	5·04	7·97	3·60	12·55	4·63	3·87	3·61	10·12	3·68	2·70	14·06	17·55	1·94	10·94	6·35	11·36	11·92	9·16	4·71	10·35	16·21	10·53	2·03	6·08	10·55	5·15	1·90	3·01	8·17	3·50	5·31	14·89	5·06	11·81	3·16	13·16	4·51	10·25	4·61	18·22	12·14	9·84	7·61	10·27	9·50	8·24	4·37	4·7
7. Avena elatior	0·07	0·21	0·13	0·05	0·78	0·67	1·84	0·76	0·62	0·64	1·62	1·65	2·04	0·40	0·52	0·15	0·13	0·18	0·15	0·05	2·46	0·41	0·49	1·02	3·93	2·78	1·49	0·23	3·44	0·50	2·60	2·77	2·61	0·06	0·46	1·29	0·42	0·16	4·40	2·17	...	2·80	11·40	13·23	9·06	11·71	13·22	9·1
8. Avena pubescens	9·63	3·07	3·55	2·69	9·87	5·64	4·85	2·87	0·50	1·86	2·76	2·06	2·56	3·93	10·28	7·68	9·42	4·97	4·09	4·05	7·38	3·94	0·29	0·03	7·31	0·63	0·24	0·12	14·54	0·90	1·83	1·67	13·91	2·90	2·36	2·25	12·68	3·44	3·66	1·67	10·22	1·41	0·49	0·07	10·64	1·64	0·44	0·2
9. Avena flavescens	2·37	1·96	3·49	1·06	2·25	1·76	2·36	0·55	3·99	0·65	0·23	1·37	0·02	5·81	11·62	2·92	4·72	4·28	6·09	2·47	2·09	0·41	0·09	0·03	0·65	0·46	0·16	0·01	1·19	0·24	1·49	0·48	4·02	4·84	3·72	3·65	3·42	2·52	3·94	2·45	9·08	3·78	5·30	0·67	10·05	2·00	0·17	0·1
10. Poa pratensis	0·29	0·17	0·09	0·07	0·72	0·68	0·72	0·27	1·45	6·06	7·41	1·36	1·66	3·54	2·25	1·20	0·56	0·28	0·45	0·02	0·67	3·87	5·11	1·56	1·07	0·65	0·61	0·23	2·58	1·65	2·42	1·74	1·15	1·05	2·27	1·75	1·72	1·50	2·11	1·03	10·66	13·02	22·87	18·03	4·06	14·91	19·62	6·4
11. Poa trivialis	1·54	1·17	0·50	0·56	2·64	1·93	0·91	0·90	31·90	22·32	4·35	2·71	29·18	15·75	3·07	2·37	5·16	5·65	3·79	4·72	8·14	2·15	2·10	0·31	0·89	0·30	0·59	0·01	1·53	0·40	0·96	0·63	3·81	4·38	2·30	2·17	5·48	3·49	1·62	3·20	6·72	2·14	0·64	0·11	10·18	2·76	1·23	0·4
12. Briza media	3·69	0·68	6·40	7·25	1·37	1·66	4·22	3·72	...	...	0·02	0·17	...	...	0·01	0·01	0·56	0·22	2·12	2·16	...	...	0·01	...	0·06	...	0·03	0·02	0·03	0·06	0·01	0·04	0·03	0·06	0·10	0·14	0·07	0·08	1·16	0·57	...	...	0·64	1·01	...	...	...	...	...	...	...	...	...	...
13. Dactylis glomerata	1·76	1·74	0·80	0·70	2·82	3·19	1·90	2·64	16·43	6·43	3·31	4·23	4·51	3·51	2·27	2·79	2·25	0·99	0·57	1·41	2·28	0·38	0·18	1·83	2·89	1·39	0·76	2·35	2·05	1·71	1·24	4·09	2·07	4·67	1·66	2·67	3·86	1·48	0·66	0·96	0·58	4·64	11·89	14·07	12·51	5·44	2·12	4·5
14. Cynosurus cristatu	0·17	0·13	1·11	0·98	0·49	0·43	0·96	0·44	0·02	0·07	0·02	0·01	0·01	0·28	0·78	0·98	0·34	0·84	1·03	0·80	...	...	...	...	0·01	0·01	0·01	...	0·01	0·03	0·01	...	0·09	0·22	0·06	0·10	0·25	0·24	1·02	1·14	...	...	...	...	0·01	0·01	...	...	0·01	0·01	...	...
15. Festuca ovina	13·90	19·20	21·67	21·99	7·17	11·59	16·05	25·96	0·76	0·17	0·46	10·75	0·37	4·55	9·89	11·23	10·20	16·75	29·44	16·02	6·90	26·09	42·29	55·20	21·99	30·57	46·56	55·31	13·23	25·93	31·15	36·02	13·73	11·34	14·96	26·50	7·51	17·74	22·95	19·76	8·21	19·42	8·83	21·90	4·08	14·74	19·90	26·1
16. Festuca pratensis	0·04	...	0·01	0·01	10·11	3·94	2·25	3·27	...	...	0·01	...	...	0·02	0·04	0·34	0·13	...	0·08	0·02	0·46	0·01	...	...	0·35	0·13	0·02	...	0·44	0·01	0·01	0·14	0·17	0·44	0·11	0·05	2·21	0·42	2·33	0·84	1·42	0·07	0·03	...	1·48	0·25	0·09	0·2
17. Festuca elatior	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·08	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18. Festuca ovina	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19. Bromus mollis	0·13	0·05	0·01	...	0·08	0·04	0·01	0·01	21·92	10·55	4·55	0·83	17·77	16·20	3·89	0·18	0·52	0·43	0·09	0·01	0·33	0·20	0·02	...	0·08	...	...	...	0·15	...	...	...	1·38	0·43	0·09	0·01	4·46	1·11	0·10	...	2·53	0·89	1·74	1·1
20. Lolium perenne	0·37	4·03	2·37	4·55	0·46	3·09	1·91	2·28	1·42	3·19	1·71	1·06	1·43	3·63	3·17	4·92	9·28	5·24	3·12	4·55	0·47	1·36	0·70	0·21	3·33	1·21	0·97	0·09	4·58	1·39	0·68	1·97	3·12	2·40	0·59	3·02	5·92	2·61	1·92	7·63	4·20	1·01	1·11	0·16	3·02	1·94	0·57	0·2
Gramineæ Determined	62·77	59·39	65·70	71·15	64·07	56·02	62·36	68·33	63·90	84·44	81·99	83·96	72·40	82·23	79·15	75·42	66·70	64·15	66·21	71·78	73·57	63·62	86·31	84·63	82·87	70·24	83·75	84·08	78·75	60·57	78·42	79·96	61·76	56·99	47·36	74·39	69·30	60·54	70·26	81·19	86·03	74·03	90·40	94·65	81·09	81·02	92·74	93·6
Undetermined, chiefly Gramineæ	7·84	6·14	2·96	...	3·67	1·98	0·22	...	5·07	1·66	0·22	...	2·65	2·29	0·87	...	3·28	2·78	0·82	...	4·74	2·51	0·34	...	3·45	1·61	0·25	...	2·89	2·40	1·46	...	2·39	2·49	1·30	...	2·56	3·03	1·79	...	4·36	1·61	1·94	...
Total	70·61	65·53	68·66	71·15	72·44	59·02	63·70	68·33	68·97	86·43	82·21	83·96	75·05	84·52	80·02	75·42	74·96	66·93	67·03	71·78	80·31	66·13	86·65	84·63	86·32	71·85	84·70	84·08	80·52	62·66	79·23	79·96	64·65	59·29	48·82	74·38	71·69	63·03	71·56	81·19	89·59	77·06	92·19	94·65	85·45	82·63	94·69	93·6
LEGUMINOUS HERBAGE.																																								
Number of Species	4	4	4	4	4	4	4	4	4	4	3	2	3	4	4	4	4	4	5	5	3	3	2	2	4	4	3	2	4	3	4	4	4	4	4	4	2	2	1	4	2	1	2	2
1. Trifolium repens	0·53	0·21	0·39	0·13	0·53	1·65	1·10	0·03	0·03	0·07	0·01	0·01	0·60	0·06	0·52	0·16	0·61	0·09	0·48	0·35	0·01	0·01	...	0·01	0·01	0·01	0·01	...	0·01	0·01	0·01	0·01	3·08	0·47	1·77	0·01	2·70	0·10	0·25	0·10	0·01	0·01	...	...	0·01	...	0·01	...
2. Trifolium pratense	4·48	2·11	1·68	2·09	2·06	2·87	1·58	2·07	0·03	0·05	0·01	...	0·34	0·30	0·28	0·06	1·45	0·17	0·11	0·30	0·03	0·01	...	...	0·04	0·01	...	...	0·04	0·01	0·04	0·06	0·84	4·75	1·13	1·55	7·71	1·13	0·27	0·36	...	...	...	...	...	...	...	...
3. Trifolium minus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	...	...	...
4. Trifolium procumbens	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5. Lotus corniculatus	1·83	2·35	5·94	3·95	1·64	4·26	5·16	3·09	0·01	0·01	...	...	...	0·10	0·17	0·17	0·41	1·23	3·71	0·96	...	...	...	...	0·05	0·31	0·41	0·14	0·01	0·08	0·06	0·03	1·27	0·69	0·19	0·04	0·15	0·83	3·51	1·18	...	...	...	...	...	...	...	...
6. Lotus major	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7. Lathyrus pratensis	1·28	0·68	0·98	2·97	1·95	2·01	2·33	2·29	0·12	0·65	0·32	0·50	0·98	1·17	2·96	5·25	0·32	1·34	4·19	2·38	0·07	0·03	0·02	0·03	0·02	0·01	0·04	0·05	0·23	...	1·47	0·56	13·51	6·78	36·63	12·11	9·76	6·82	3·94	2·37	0·12	0·15	0·02	0·06	0·11	0·09	0·01	0·2
8. Onobis arvensis	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·12	0·64	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9. Vicia Cracca	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	8·10	5·35	8·98	8·54	6·20	10·79	10·17	7·48	0·19	0·98	0·34	0·51	1·92	1·63	4·93	5·54	2·79	2·83	8·61	5·53	0·09	0·04	0·03	0·04	0·12	0·34	0·46	0·19	0·28	0·10	1·58	0·68	24·70	12·69	39·77	13·71	19·32	8·88	7·97	4·01	0·13	0·16	0·02	0·41	0·12	0·08	0·02	0·2
MISCELLANEOUS HERBAGE.																																								
Number of Species	28	24	29	31	24	30	29	31	9	15	15	17	13	20	25	30	26	27	28	24	18	13	11	11	17	17	13	14	15	15	18	20	22	22	20	23	17	21	21	28	13	13	13	10	13	11	6	1
Ranunculaceæ — 1. Ranunculus acris	0·01	0·01	0·07	...	...	0·35	0·04	0·09	...	0·26	0·14	1·30	...	0·02	1·02	1·49	0·03	0·10	0·12	0·28	0·01	0·01	...	...	0·01	0·02	0·03	0·07	...	...	0·35	0·34	0·08	0·12	0·19	0·37	...	0·06	0·47	1·09	...	...	...	...	0·01	...	...	...
Ranunculaceæ — 2 and 3. Ranunculus repens et bulbosus	4·89	2·01	2·94	3·45	2·62	1·72	3·22	6·45	1·53	0·37	0·58	1·28	2·69	0·99	1·53	3·58	5·97	1·29	4·16	5·84	2·14	0·04	0·01	...	0·32	0·08	0·08	0·09	0·77	0·16	0·12	0·23	1·31	0·38	0·21	0·32	1·16	0·55	1·00	0·65	0·14	0·05	...	0·04	0·36	0·03	...	...
Ranunculaceæ — 4. Ranunculus auricomus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Caryophyllæ — 5. Stellaria graminea	0·01	0·02	...	0·02	0·07	0·42	0·90	0·94	...	...	0·01	...	0·04	0·01	0·16	0·05	0·03	0·17	0·07	0·15	0·01	0·02	...	...	0·20	0·09	...	...	...	0·01	0·01	0·01	0·02	0·09	0·04	0·07	...	0·03	...	...	...	...	...	...	...
Caryophyllæ — 6. Stellaria Holostea	...	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Caryophyllæ — 7. Cerastium triviale	0·46	0·37	0·85	0·62	0·39	1·02	3·44	0·81	...	0·11	0·24	0·47	0·01	0·05	1·22	0·40	0·43	0·97	0·85	0·74	0·01	0·01	0·01	...	0·01	0·09	...	...	0·07	0·04	0·02	0·01	0·05	0·02	0·01	0·01	0·08	0·11	0·33	0·17	...	...	...	...	0·01	...	...	...
Hypericineæ — 8. Hypericum perforatum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rosaceæ — 9. Potentilla reptans	...	...	0·01	0·01	0·01	0·01	0·01	0·02	0·02	...	...	...	...	...	0·01	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	0·01	0·01	...	...	...	...	...	0·05	...	0·01	0·10	0·01	0·01	...
Rosaceæ — 10. Potentilla Fragariastrum	...	...	...	...	...	0·01	0·01	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rosaceæ — 11. Agrimonia Eupatoria	0·01	...	0·02	0·01	...	0·01	0·01	0·01	...	...	...	...	...	...	0·09	0·02	...	...	...	...	...	...	...	...	...	...	...	...	0·02	...	...	...	...	...	...	...	0·01	...	0·01	0·01	...	...	...	...
Rosaceæ — 12. Poterium Sanguisorba	...	0·21	0·49	0·88	...	...	0·01	...	...	...	...	...	...	...	...	0·01	0·01	0·75	0·09	0·21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rosaceæ — 13. Spiræa Ulmaria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Umbelliferæ — 14. Conopodium denudatum	0·97	2·95	2·85	1·90	1·58	0·42	2·17	2·84	0·07	0·46	1·59	0·56	0·56	0·53	2·85	1·13	0·96	0·97	2·72	1·17	0·84	1·29	2·85	0·39	0·11	1·15	5·74	1·03	0·85	0·55	7·87	2·47	0·88	2·03	9·22	1·31	1·56	0·59	6·84	1·73	0·07	0·02	2·92	0·35	0·01	0·02	1·49	0·07	...
Umbelliferæ — 15. Pimpinella Saxifragra	1·53	3·44	0·86	0·79	0·99	1·20	0·44	0·49	0·07	0·03	0·03	0·02	0·36	0·48	0·17	0·27	0·87	3·21	1·28	1·48	0·60	0·39	0·36	0·01	0·10	0·77	0·15	0·01	0·06	0·61	0·26	0·13	0·86	1·20	0·22	0·28	0·81	1·91	1·05	0·67	0·01	0·01	0·01	0·01	0·17	0·17	0·12	0·0
Umbelliferæ — 16. Heracleum Sphondylium	...	...	0·02	...	...	...	...	...	...	...	...	...	...	...	0·04	...	...	...	0·02	...	0·03	...	...	...	...	...	...	...	...	...	0·15	0·16	...	...	0·21	0·02	0·57	...	...	...	0·22	...	...	0·06	0·15	...	...	...
Umbelliferæ — 17. Anthriscus sylvestris	...	...	...	...	...	0·28	...	...	...	...	...	...	0·02	0·02	...	...	...	...	...	...	0·24	...	...	...	...	...	0·01	0·05	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rubiaceæ — 18. Galium verum	...	...	...	...	0·01	0·11	0·01	0·01	...	...	...	...	0·01	0·02	0·06	0·04	...	...	...	0·01	0·09	0·50	0·86	0·68	...	0·61	2·40	0·22	0·97	0·33	0·90	0·16	...	...	...	0·06	...	...	...	...	...	...	...	...	...	...
Dipsaceæ — 19. Galium Aparine	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dipsaceæ — 20. Scabiosa arvensis	0·01	...	0·02	0·12	0·05	0·01	0·09	0·06	...	...	...	...	...	...	0·10	...	...	...	0·01	...	...	...	0·01	0·05	0·03	0·23	0·62	...	0·06	0·06	0·01	0·01	0·01	0·07	...	...	...	...	...	...	...	...	...	...	...
Compositæ — 21. Centaurea nigra	0·31	0·59	2·11	1·06	1·20	0·94	3·35	2·47	...	0·18	1·24	0·25	0·04	0·14	1·28	0·90	0·43	0·36	1·01	0·66	0·01	0·21	1·25	0·85	0·01	2·43	2·18	0·53	...	1·40	1·41	0·44	0·03	0·79	0·27	0·10	0·22	0·45	0·24	0·76	0·04	...	0·02	0·17	...	...	0·20	...
Compositæ — 22. Cardiuus arvensis	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·11	0·79	0·28	0·10	...	...	...	...	...	...	...
Compositæ — 23. Bellis perennis	0·01	0·04	0·01	0·02	...	0·01	0·01	...	...	...	...	...	0·01	0·01	0·01	0·01	0·01	0·05	0·01	0·02	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Compositæ — 24. Achillea Millefolium	1·53	1·16	1·78	1·99	1·13	1·53	3·77	2·91	1·35	3·07	5·01	0·72	2·41	1·09	2·93	2·17	1·42	1·98	0·38	3·19	1·77	1·49	1·75	0·27	1·83	1·09	1·05	0·16	3·34	1·08	4·09	1·72	1·69	3·10	5·23	0·64	0·93	4·89	9·73	2·76	1·95	2·03	1·50	0·04	0·87	1·91	0·80	0·3
Compositæ — 25. Chrysanthemum Leucanthemum	...	...	...	...	0·12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Compositæ — 26. Tragopogon pratensis	0·01	...	0·01	0·01	0·80	0·36	0·03	0·01	...	...	...	...	0·02	0·02	0·02	0·04	0·59	0·62	0·11	0·02	...	...	...	...	...	...	...	...	0·20	0·13	...	...	...	...	0·01	0·72	...	...	...	...	...	...	...
Compositæ — 27. Leontodon hispidus	0·06	0·64	1·27	1·32	0·11	0·10	0·13	0·07	...	...	...	...	0·02	0·02	0·04	0·59	0·62	0·11	0·02	...	...	...	...	...	...	...	...	...	0·04	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Compositæ — 28. Leontodon autumnalis	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	0·01	0·07	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Compositæ — 29. Taraxacum officinale	0·05	0·16	0·15	0·06	0·12	0·13	0·01	0·14	0·02	0·17	0·13	0·03	...	0·14	0·24	0·25	0·34	0·13	0·07	0·01	...	...	...	...	0·01	0·01	0·02	...	0·16	0·10	...	...	0·03

amsted, illustrating the Domination of one Plant over another in the Mixed Herbage of Permanent Meadow Land.

oup (Gramineæ, Leguminosæ, and Miscellaneæ), in the total Mixed Herbage of each Plot, in each year of complete botanical separation, 1862, 1867, 1872, and 1877.

	"Mixed Mineral Manure"—Sulphates of Potass, Soda, and Magnesia, and Superphosphate of Lime.																				Nitrate of Soda alone.								Mineral Constituents and Nitrogen of 1 ton Hay.				Superphosphate, Nitrate Soda, and Sulphate Potass.		Superphosphate, and Nitrate Potass.		Description of Manure.
, each year, 1856 and since.		With Potass, 6 years, 1856–61; without Potass, 1862 and since.		With Ammonia-salts = 86 lbs. Nitrogen.		Mineral Manures as Plot 8, and Ammonia-salts = 86 lbs. Nitrogen.		With Ammonia-salts = 172 lbs. Nitrogen; only 86 lbs. in 1859–60–61.		As Plot 11—1 and Silicates in addition, 1862, and since.		With Ammonia-salts = 86 lbs. Nitrogen and Cut Wheat Straw.				With Nitrate of Soda = 86 lbs. Nitrogen.		With Nitrate of Soda = 43 lbs. Nitrogen.		= 86 lbs. Nitrogen.		= 43 lbs. Nitrogen.												Description of Manure.
7		8		9		10		11–1		11–2		13–1		13–2		14		16		15		17								18		19		20		Plot Numbers.
1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1867	1872	1877	1872	1877	1872	1877	Seasons.

Gramineous Herbage.

																																						Number of Species.
2·93	2·72	3·16	3·72	6·98	7·94	7·55	1·24	3·39	2·25	2·94	1·46	5·27	3·26	5·84	0·07	0·06	0·78	0·19	1·00	0·10	0·16	0·17	0·61	2·44	0·48	0·43	0·77	1·33	0·36	0·23	0·35	0·13	0·02	0·06	1·42	1·78	1·40	2·22	1·82	1·83	4·49	4·16	2·06	2·31	4·50	5·32	4·94	7·11	8·64	6·39	2·47	7·17	9·31	Ordinary English names:—
0·88	1·17	0·48	0·39	0·88	0·52	0·87	0·27	0·07	2·78	0·96	2·05	2·99	10·35	16·51	2·80	13·11	12·35	9·91	1·50	0·33	22·65	20·11	4·73	4·49	9·81	9·57	2·00	4·57	1·97	3·99	0·22	3·84	3·72	20·18	0·67	8·27	15·22	12·23	6·90	5·95	2·46	7·17	23·94	21·71	16·25	12·72	0·23	3·40	1·22	6·80	Sweet-scented Vernal Grass	1
																							0·05								0·07	0·18	0·07		0·07	0·16	0·07		0·01	0·01			Meadow Fox Tail	2
5·69	11·72	12·02	10·01	4·32	9·32	12·40	12·81	13·43	15·46	12·23	9·37	6·61	14·17	16·29	13·17	19·27	13·56	20·30	16·81	24·16	10·16	17·09	15·21	16·72	15·78	13·27	8·53	23·97	11·10	13·53	0·43	0·61	0·24	1·55	12·49	13·62	12·40	14·58	7·65	6·96	7·66	12·90	11·01	7·05	10·60	17·92	7·29	21·95	16·40	22·56	10·83	31·35	10·36	Meadow Cat's Tail	3
...	0·01	0·01	0·01	0·01	0·01	0·01	...	...	0·01	0·01	...	...	0·01	0·01	...	...	0·01	0·01	...	...	0·01	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	0·02	...	...	...	0·01	0·01	0·01	0·01	Common Bent	4
11·41	3·16	12·16	4·01	10·25	4·01	18·42	11·14	9·84	7·61	10·47	3·50	8·24	9·37	4·74	5·39	6·46	5·09	4·34	0·60	0·63	3·67	12·75	10·45	11·69	8·26	12·84	7·61	11·81	9·32	14·95	9·23	9·13	5·47	10·91	14·03	21·19	12·39	29·47	Tufted Hair Grass	5
0·06	0·46	1·29	4·32	3·16	4·40	3·17	...	2·50	11·40	13·23	0·08	11·71	13·22	9·38	0·77	4·55	10·41	14·26	0·40	4·83	12·73	21·14	0·68	3·65	8·44	10·47	0·16	1·32	9·91	11·70	3·14	...	0·32	...	0·12	...	0·17	0·08	0·04	...	0·01	...	...	0·09	0·23	0·46	0·01	...	0·01	0·01	Woolly Soft Grass	6
2·90	2·36	2·25	12·68	3·44	3·66	1·67	10·22	1·41	0·49	0·07	10·84	1·84	0·44	0·24	1·98	0·01	...	...	0·76	0·01	...	...	9·14	0·81	0·16	0·03	1·49	1·72	1·54	3·34	3·53	0·70	1·06	3·13	4·34	1·15	4·08	4·27	False Oats	7
4·94	3·72	2·85	5·42	3·52	6·94	2·45	9·08	3·78	5·30	0·67	4·20	2·00	0·17	0·16	5·26	0·46	0·09	0·01	3·42	1·75	0·41	0·02	4·20	4·34	1·33	0·37	0·48	4·20	2·07	0·76	4·88	7·12	5·67	2·93	19·37	14·96	19·90	6·67	3·43	5·75	3·12	3·29	4·37	3·07	2·40	Downy Oat	8
1·05	2·27	1·75	1·72	1·50	2·11	1·03	10·68	13·02	22·67	18·03	4·06	14·91	19·62	6·48	9·43	12·86	10·40	1·47	5·12	10·39	12·43	4·50	5·73	13·69	16·30	11·92	2·08	6·81	6·59	8·28	1·45	1·05	2·57	4·01	0·02	0·10	0·39	0·48	0·14	0·13	0·37	0·11	0·02	0·21	0·09	0·09	0·05	0·12	0·01	0·01	Yellow Oat	9
4·38	2·30	2·11	5·48	3·49	1·82	3·20	8·72	2·14	0·64	0·11	10·18	2·78	1·21	0·47	13·25	0·14	0·09	0·33	17·04	1·52	0·81	0·01	10·09	4·16	1·02	0·77	13·58	9·21	3·20	0·51	22·48	32·93	24·76	21·59	0·87	8·96	6·83	4·82	6·53	23·67	7·95	6·05	5·21	12·08	2·74	1·59	4·83	2·92	2·90	0·75	4·73	3·29	0·06	Smooth Stalked Meadow Grass	10
0·06	0·10	0·14	0·07	0·06	1·16	0·57	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·05	0·03	0·20	0·20	0·01	0·07	0·31	0·72	0·02	0·45	0·12	0·75	0·04	0·72	0·19	Rough Stalked Meadow	11
4·67	1·68	3·67	3·80	1·48	0·66	0·98	5·58	4·64	11·88	14·07	2·01	0·01	0·01	0·01	24·18	39·31	39·28	17·11	23·34	36·30	27·23	13·38	23·40	16·29	31·28	37·04	32·36	24·28	54·94	44·46	10·00	7·23	3·33	12·48	1·50	2·59	3·75	4·63	2·09	2·21	2·11	0·36	1·00	0·57	0·64	0·56	0·07	0·03	0·01	0·13	Quaking	12
0·22	0·09	0·10	0·23	0·24	1·02	1·14	...	...	...	...	0·01	0·01	0·01	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	0·16	0·30	0·05	0·16	0·12	0·41	0·30	0·81	0·18	0·97	0·32	1·17	2·54	1·15	1·51	Cock's Foot	13
11·30	14·96	20·50	2·39	2·49	1·30	...	5·21	15·42	8·48	21·90	4·36	1·61	1·94	...	2·72	0·87	1·16	...	4·39	0·94	1·60	...	3·47	1·48	1·46	...	6·77	1·74	1·30	...	5·48	5·21	0·79	...	4·99	1·04	0·50	...	7·40	1·86	0·58	...	3·11	0·90	...	0·73	...	0·74	...	Crested Dog's Tail	14
0·94	0·11	0·95	2·21	0·42	0·33	0·94	1·42	0·07	0·03	...	1·49	0·25	0·09	0·14	1·90	...	...	...	2·28	0·06	...	...	3·20	0·53	0·02	0·01	4·56	0·61	0·07	0·04	0·87	0·03	0·09	0·33	0·32	0·19	0·27	0·09	0·03	0·27	0·03	1·47	0·49	0·09	0·04	0·08	0·97	0·62	0·03	0·42	0·67	...	0·03	Sheep Fescue	15
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Meadow Fescue	16
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Tall Meadow Fescue	17
2·38	0·04	0·01	1·38	0·43	0·09	0·01	4·46	0·11	0·10	...	2·53	0·89	1·74	1·55	1·39	0·04	0·01	...	0·69	0·07	0·01	...	0·56	0·09	0·01	0·01	0·70	0·01	0·01	...	19·04	17·69	42·10	8·02	2·04	2·64	2·03	0·57	2·12	6·27	4·00	1·65	0·18	2·26	0·81	0·15	0·01	0·01	...	0·32	...	...	Spiked Meadow Fescue	18
2·40	0·59	3·02	8·92	2·81	1·92	7·63	4·20	1·01	1·11	0·16	3·02	1·84	0·57	0·17	1·37	0·08	...	0·01	1·46	0·38	0·16	...	1·73	1·24	0·08	0·15	3·78	1·18	0·23	0·07	13·80	9·36	5·55	2·63	5·56	6·23	3·10	3·75	7·40	3·24	4·42	7·22	5·09	3·23	2·94	6·63	0·15	3·37	6·45	4·14	1·23	2·03	3·61	Soft Brome Grass	19
																																										Perennial Rye	20
56·09	47·36	74·39	69·30	60·54	70·26	81·19	66·03	74·03	90·40	94·85	61·09	61·02	92·74	93·42	86·66	93·25	97·68	97·53	89·85	94·73	97·66	96·46	86·22	84·45	92·65	93·53	84·42	84·97	95·37	90·56	84·04	89·04	92·08	87·81	73·02	83·39	81·68	82·94	63·69	77·51	77·80	83·45	73·96	73·96	72·69	75·97	52·35	80·00	84·19	88·92	80·95	96·36	90·11	Gramineæ Determined.
2·40	1·46	...	2·39	2·49	1·30	...	2·56	3·03	1·79	...	4·36	1·61	1·94	...	2·72	0·87	1·16	...	4·39	0·94	1·60	...	3·47	1·48	1·46	...	6·77	1·74	1·30	...	5·48	5·21	0·79	...	4·99	1·04	0·50	...	7·40	1·86	0·58	...	3·11	0·90	...	0·73	...	0·74	...	Chiefly Gramineæ Undetermined.
59·29	48·82	74·39	71·69	63·03	71·56	81·19	68·59	77·06	92·19	94·85	65·45	62·63	94·68	93·42	89·38	94·12	98·84	97·53	94·24	95·67	99·26	98·46	89·69	85·93	94·11	93·53	91·19	86·71	96·67	90·56	89·52	94·25	92·87	87·81	79·01	84·43	81·56	82·94	78·28	80·02	78·76	83·45	81·36	78·72	73·27	75·97	55·46	80·80	84·19	89·35	80·95	97·12	90·11	Total.

Leguminous Herbage.

																																						Number of Species.
0·47	1·77	0·01	2·70	0·10	0·28	0·10	0·01	0·01	...	...	0·01	...	0·01	...	...	...	0·01	...	...	...	...	...	0·04	0·04	0·01	...	0·03	0·02	...	...	0·01	0·01	...	...	0·35	0·50	0·32	0·01	0·04	0·06	0·06	0·01	0·05	0·32	0·09	0·01	0·42	0·56	0·03	0·19	0·94	0·21	0·64	White or Dutch Clover	1
4·75	1·13	1·56	7·71	1·13	0·27	0·36	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	0·01	0·01	...	1·85	0·70	0·43	0·11	3·02	0·04	0·03	0·01	0·31	0·26	0·13	0·11	3·02	0·04	0·03	1·90	0·07	2·63	0·05	Common Red Clover	2
...	...	...	...	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Lesser Clover	3
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	Hop Trefoil	4
0·69	0·19	0·04	0·15	0·83	3·51	1·18	...	...	...	...	...	...	...	...	0·01	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	0·02	0·02	0·06	...	0·02	0·35	0·03	0·01	0·03	0·12	1·16	0·78	0·71	1·38	0·28	0·79	0·12	1·09	0·34	Bird's Foot Trefoil	5
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Greater Bird's Foot Trefoil	6
6·78	36·68	12·11	9·76	6·82	3·94	2·37	0·12	0·15	0·02	0·06	0·11	0·08	0·01	...	0·01	...	...	...	0·44	0·13	0·59	...	0·03	0·05	0·01	...	0·11	0·37	1·35	0·76	0·04	0·57	0·68	9·22	...	0·04	...	1·47	0·01	...	0·01	0·01	0·01	0·83	1·07	1·50	0·23	0·92	0·16	2·73	Meadow Vetchling	7
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Tufted Vetch	8
...	...	...	...	...	...	...	...	...	...	0·33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Tufted Vetch	9
12·69	39·77	13·71	19·32	9·88	7·97	4·01	0·13	0·16	0·02	0·41	0·12	0·08	0·02	0·02	0·01	0·01	0·01	...	...	...	...	...	0·53	0·17	0·61	...	0·06	0·07	0·03	...	0·13	0·39	1·36	0·76	2·24	1·79	7·45	9·40	0·27	0·81	0·12	1·80	0·42	0·70	1·38	0·91	5·01	3·57	1·99	2·81	6·73	2·04	3·66	Total.

Miscellaneous Herbage.

																																										Number of Species.
0·12	0·19	0·37	...	0·66	0·47	1·09	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	0·05	0·06	...	...	0·01	...	...	...	1·23	0·30	0·20	0·71	0·95	0·05	0·79	1·24	0·46	0·25	1·24	3·74	0·14	0·29	1·15	2·95	0·31	0·73	0·46	0·30	0·61	0·01	0·19	Upright Crowfoot or Buttercup	1
0·28	0·21	0·32	1·16	0·55	1·00	0·65	0·14	0·05	...	0·04	0·36	0·03	...	...	0·03	...	...	...	0·08	0·01	...	...	0·01	...	0·01	...	1·23	0·10	0·03	...	4·66	0·33	0·33	0·26	1·80	0·39	0·39	0·49	1·95	1·04	1·33	1·96	5·73	3·11	2·06	2·02	0·19	3·93	3·83	Creeping and bulbous Buttercup	2 and 3
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·13	...	...	...	...	...	...	...	Goldilocks	4
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	Lesser Stitchwort	5
0·01	0·01	0·02	0·09	0·04	0·06	0·02	...	0·03	...	...	...	...	...	...	...	...	...	...	0·04	0·09	0·01	0·01	0·02	0·05	...	...	...	...	...	...	...	0·24	0·03	...	...	0·08	0·04	0·01	0·06	0·26	0·19	0·02	0·01	0·01	...	...	Greater Stitchwort	6
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Mouse-ear Chickweed	7
0·02	0·01	0·01	0·08	0·11	0·33	0·17	...	...	...	...	0·01	...	...	...	...	...	...	...	0·07	...	...	...	0·01	...	...	...	0·01	0·01	0·01	0·06	0·03	0·06	0·02	0·07	1·97	3·88	9·28	3·59	0·39	1·00	0·05	0·39	0·12	0·18	0·08	0·41	0·20	0·45	0·20	Perforated St. John's Wort	8
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·01	...	...	...	...	...	...	Creeping Cinque Foil	9
...	0·01	...	...	...	...	...	0·03	...	0·01	0·10	0·01	0·01	...	0·11	...	...	...	...	...	0·01	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	0·02	0·01	...	...	0·01	...	...	...	Barren Strawberry	10
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Common Agrimony	11
0·02	...	...	...	...	...	0·01	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Common Burnet	12
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Meadow Sweet	13
0·25	0·06	0·17	...	...	...	0·02	...	...	0·01	0·02	0·49	0·07	...	0·04	...	...	...	...	...	...	...	...	2·12	0·17	0·06	1·25	1·87	7·91	0·67	0·79	0·01	0·18	0·50	4·60	3·90	0·51	0·58	0·20	0·43	0·77	1·48	2·44	1·81	0·72	2·69	2·42	3·18	1·96	4·47	2·02	2·66	Earth or Pig Nut	14
9·22	1·31	1·88	1·59	0·84	1·73	1·07	2·92	9·35	1·51	0·75	1·77	2·49	0·06	0·06	1·79	1·84	0·04	0·01	1·19	0·70	0·03	0·01	2·12	0·17	0·06	1·25	1·87	7·91	0·67	0·79	1·55	1·57	0·61	0·18	4·50	4·60	3·90	0·51	0·58	0·20	0·43	0·77	1·48	2·44	1·81	0·72	2·69	2·42	3·18	1·96	4·47	2·02	2·66	Burnet Saxifrage	15
1·30	0·22	0·28	0·91	1·91	1·03	0·67	0·01	0·01	0·01	0·01	0·17	0·12	0·01	0·01	0·06	...	...	...	0·01	...	...	...	0·07	0·02	0·01	...	0·01	0·01	...	...	0·03	0·02	0·02	0·01	0·01	...	0·01	0·02	0·01	0·02	0·07	0·04	0·02	0·07	0·04	0·01	0·02	0·01	0·01	0·01	0·01	0·01	0·01	Cow Parsnip or Hogweed	16
0·21	0·02	0·57	...	...	...	0·22	...	...	0·06	0·15	...	...	...	...	...	...	...	0·20	...	...	0·01	0·18	...	0·07	0·08	0·04	...	...	0·27	0·01	0·04	...	...	...	0·48	...	...	...	0·11	0·16	...	...	...	...	...	...	...	...	...	...	...	Beaked Parsley	17
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·08	...	...	...	1·52	3·96	4·64	...	...	0·02	0·02	...	0·01	1·06	1·21	0·23	...	...	...	0·02	0·77	0·01	...	0·01	0·04	Yellow Bed Straw	18
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·04	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Clusters or Goose Grass	19
...	...	0·01	0·03	0·40	0·36	0·03	...	...	...	0·06	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Field Scabious	20
...	...	0·06	0·06	0·01	0·08	0·01	0·08	0·47	...	...	...	...	...	...	...	...	...	...	...	0·04	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Black Knapweed	21
...	...	0·07	0·10	0·22	0·45	0·24	0·76	0·04	...	0·33	0·08	0·17	...	...	...	...	...	...	0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Creeping Plume Thistle	22
0·79	0·27	0·10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Daisy	23
0·79	0·26	0·10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Yarrow or Milfoil	24
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Oxeye Daisy	25
3·10	5·23	0·64	2·93	4·89	9·78	3·76	1·95	2·03	1·50	0·04	0·87	1·91	0·80	0·03	1·45	0·06	...	0·01	0·43	0·01	...	...	1·93	1·20	1·12	0·01	0·75	1·72	0·16	0·01	0·24	0·47	0·21	0·65	2·47	1·76	3·29	1·55	2·53	1·13	2·60	0·58	2·14	1·39	2·91	1·39	0·76	4·06	1·32	0·68	0·06	0·78	0·80	Goat's Beard	26
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Rough Hawkbit	27
0·20	0·13	...	...	...	0·01	...	0·01	0·72	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Autumnal Hawkbit	28
0·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Dandelion	29
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Mouse-ear Hawkbit	30
0·10	...	...	0·03	0·10	0·05	0·01	...	...	...	...	0·31	0·01	...	...	0·15	...	...	...	0·04	...	...	...	0·06	...	...	...	0·10	...	...	...	0·19	0·23	0·18	0·63	0·16	0·01	...	0·03	0·01	0·01	...	0·01	0·01	0·01	...	...	...	...	...	...	...	Ribwort Plantain	31
1·10	0·07	0·09	0·71	1·53	0·34	0·26	0·01	0·01	...	...	...	...	...	...	...	...	...	...

DETAILED results of Experiments at Rothamsted, illustrating the Domination

APPENDIX–TABLE XI.—Number of Species, and Quantities in lbs. per acre, of each Species, and each Group (Gramineæ, Leguminosæ, a

Description of Manure	Without Manure, 1856, and since.				Farmyard Manure, 3 years, 1856-63; discontinued 1864, and since.								Superphosphate of Lime each year, 1850, and since.								Ammonia-salts alone, = 86 lbs. Nitrogen.				1869 and since: previously (13 years, 1856-68), Ammonia-salts.				Alone, each year, 1856 and since.				With Potass, 6 years, 1856-61: without Potass, 1862 and since.				With Ammonia-s = 86 lbs. Nitrog			
					With Ammonia-salts = 43 lbs. Nitrogen.				Alone.				Alone.				With Ammonia-salts = 86 lbs. Nitrogen.																						
Plot Number	3		12		1				2				4-1				4-2				5				6				7				8				9			
Seasons	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872	1877	1862	1867	1872
GRAMINEOUS																																							
Number of Species	18	15	17	17	16	16	17	16	15	15	18	15	14	17	18	19	16	15	16	16	14	14	15	13	17	15	15	13	15	14	17	14	16	16	17	17	17	17	16	13	14	16
Botanical Names:—																																									
1. Anthoxanthum odoratum	120·6	228·5	85·5	121·0	140·0	233·5	150·2	118·5	3·9	79·4	204·1	656·2	10·1	163·5	189·8	260·1	119·0	253·5	84·0	158·0	106·5	240·2	47·0	110·8	222·4	182·2	76·4	120·7	174·5	137·6	175·5	206·5	135·4	175·2	115·2	162·2	169·3	268·9	203·9	273·6	79·4	183·2	127·5
2. Alopecurus pratensis	137·0	193·9	8·5	7·1	108·9	79·9	61·7	30·9	14·4	91·1	103·4	119·2	15·3	141·3	158·9	125·0	42·9	68·1	18·2	43·2	31·4	64·9	125·9	74·2	25·0	15·5	20·9	6·8	75·7	0·5	0·8	3·5	15·0	39·2	49·6	24·5	17·6	32·6	19·4	31·9	17·3	3·8	156·7
3. Phleum pratense	0·3	...	...	...	0·5	1·8	2·1	...	...	...	2·9	1·1	...	...	0·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·5	...	...	...	...	...	...	...	...
4. Agrostis vulgaris	340·7	287·5	269·3	313·9	222·8	169·2	250·7	287·6	22·9	379·3	732·4	1113·4	135·6	282·4	312·0	649·1	254·5	215·2	245·9	306·2	921·7	609·3	657·9	1145·3	936·5	693·3	669·2	869·7	954·1	460·0	650·5	362·2	315·3	253·7	490·4	613·0	455·9	165·2	230·3	445·4	259·1	722·8	874·7
5. Aira cæspitosa	...	...	0·2	0·9	...	...	0·2	...	...	...	0·4	0·5	...	...	...	0·4	...	...	...	...	...	...	...	...	0·4	0·3	...	...	...	...	0·6	...	2·5	...	0·6	0·4	0·5	...	0·3	...	...	...
6. Holcus lanatus	153·8	285·5	59·2	290·7	158·5	169·8	85·8	219·1	215·6	629·2	496·4	821·0	90·2	625·3	193·9	410·3	254·5	224·3	82·5	580·3	771·0	455·3	64·3	283·1	350·3	170·2	47·7	276·9	223·4	59·5	133·6	67·2	204·0	80·9	118·4	66·3	249·5	134·6	179·2	98·5	56·1	203·4	230·7
7. Avena elatior	2·1	1·0	2·1	1·2	28·7	20·4	41·4	16·4	34·4	35·6	57·2	79·1	103·2	22·9	14·7	9·4	4·2	6·4	2·7	1·5	117·0	17·8	79·2	47·9	151·4	91·9	57·4	6·8	153·1	207·5	101·6	118·9	106·6	2·7	19·5	65·3	204·5	130·9	113·0	114·9	...	134·6	645·0
8. Avena pubescens	294·5	192·3	8·4	63·6	338·6	171·9	199·2	62·1	27·8	92·9	97·4	98·4	129·5	224·6	291·0	277·4	206·4	172·9	72·5	154·8	351·0	171·5	9·0	1·4	281·7	29·8	0·6	3·5	647·3	29·7	51·6	70·5	611·0	173·9	100·0	114·7	573·8	131·6	94·0	60·5	654·3	74·9	27·7
9. Avena flavescens	72·4	62·0	57·4	22·5	77·0	53·6	53·0	11·9	221·7	402·8	220·0	64·8	304·6	336·1	229·0	109·5	134·0	151·5	107·9	76·4	99·4	17·8	2·9	1·4	25·0	15·2	4·6	0·3	82·5	7·6	42·0	20·3	177·8	218·6	157·0	189·7	249·2	134·6	179·2	98·5	56·1	203·4	230·7
10. Poa pratensis	8·9	5·7	1·3	1·7	24·6	20·7	16·2	5·8	80·6	387·7	281·6	63·3	34·0	203·5	63·7	43·2	19·2	9·2	9·0	0·6	31·9	108·4	163·2	73·3	41·2	21·5	15·3	6·8	101·5	52·7	68·3	73·0	50·0	48·8	90·2	89·3	77·8	57·4	54·2	37·3	693·7	700·7	1382·7
11. Poa trivialis	47·0	39·0	6·2	13·2	91·7	54·6	29·5	17·3	1772·6	1312·4	153·6	125·2	1432·9	940·3	98·9	48·6	127·3	200·6	67·1	146·0	367·1	83·6	67·1	14·6	34·3	9·9	14·8	0·3	68·1	12·6	27·7	28·6	168·6	195·3	97·4	107·6	247·9	133·1	41·6	118·0	859·3	115·2	36·2
12. Briza media	57·7	22·7	105·2	171·4	46·7	30·6	95·0	80·5	...	...	0·4	...	...	1·1	4·9	23·5	19·9	11·3	37·6	66·8	...	...	0·3	...	2·3	...	0·2	...	2·3	2·7	4·7	7·1	2·3	2·0	29·3	30·8	...	...	...	...	...	0·4
13. Dactylis glomerata	53·7	54·0	14·2	18·6	96·5	97·2	42·8	57·2	912·9	378·1	116·9	200·2	226·2	372·1	92·6	100·7	73·2	35·0	10·1	43·6	108·4	16·6	5·1	85·9	92·1	46·0	17·6	90·9	91·3	54·6	36·1	172·7	113·7	208·2	71·2	157·2	159·3	56·6	19·9	35·5	257·2	349·7	672·9
14. Cynosurus cristatus	5·2	4·3	1·2	2·2	16·7	13·1	21·6	9·5	1·1	4·1	0·7	0·5	0·5	16·0	2·1	35·4	11·0	29·7	3·2	24·7	4·1	0·4	0·3	0·2	0·4	0·3	0·2	...	2·5	0·8	2·3	0·1	11·3	9·2	39·2	41·3	100·0	16·1	9·5	19·6	90·9	2·3	...
15. Festuca ovina	405·9	506·5	356·7	517·5	248·5	353·3	361·5	452·0	42·2	362·9	238·0	508·7	19·7	282·4	230·0	405·6	331·7	322·9	262·2	490·4	223·4	1135·4	1574·6	2292·2	847·5	1010·6	1170·8	1575·7	593·4	527·7	679·0	1605·2	607·4	567·4	629·5	1356·1	330·7	617·0	615·0	716·1	332·5	99·4	491·1
16. Festuca pratensis	1·2	...	0·2	0·2	34·0	120·1	50·7	70·8	...	...	0·4	...	...	1·1	1·1	12·3	4·2	...	1·4	0·6	21·9	0·4	...	...	13·5	4·3	0·5	...	19·6	0·3	0·3	5·9	7·5	29·5	4·7	48·4	100·0	16·1	9·5	19·6	90·9	2·3	1·7
17. Festuca elatior	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3·6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18. Festuca loliacea	...	...	...	0·7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19. Bromus mollis	4·0	1·7	0·2	...	2·7	1·2	0·2	0·2	1217·8	620·3	160·7	39·3	899·2	938·8	110·1	0·3	16·9	15·2	1·8	0·4	15·7	9·7	0·6	...	3·1	...	...	...	0·7	...	0·3	...	55·7	43·5	1·7	0·5	62·4	16·4	2·3	0·4	266·5	5·9	0·7
20. Lolium perenne	194·4	134·3	39·0	107·6	132·7	94·2	42·0	49·4	78·9	187·6	60·4	79·6	72·4	207·5	89·8	177·7	301·6	180·7	58·3	134·5	307·7	59·2	22·4	9·9	128·2	40·0	24·3	2·7	203·9	44·4	19·5	63·2	13·0	107·0	22·0	184·0	267·8	99·3	49·3	176·5	289·9	84·3	62·0
Gramineæ Determined	1915·7	1979·9	1080·1	1682·0	2193·9	1707·5	1404·3	1479·3	4861·5	4965·1	2895·1	3973·0	3863·4	4700·3	2240·7	2734·2	2169·1	2270·9	1173·2	2219·5	3894·1	3639·1	2821·5	4443·8	3193·8	2322·1	2103·5	2776·7	3505·9	1933·4	2212·9	3375·9	2732·3	2526·2	2006·2	3792·3	3135·1	2310·0	1804·3	2942·3	5507·6	3084·3	5114·6
Undetermined, chiefly Gramineæ	239·3	204·5	48·7	...	236·5	91·4	30·2	...	281·6	117·0	7·7	...	134·1	130·9	24·6	...	268·6	90·6	14·5	...	225·4	109·3	10·8	...	133·0	53·3	23·9	...	78·8	66·7	22·9	...	127·9	107·0	61·6	...	156·0	63·1	101·2
Total	2155·0	2183·4	1128·8	1682·0	2430·3	1798·9	1434·5	1479·3	5143·1	5082·1	2902·8	3973·0	3997·5	4831·1	2265·3	2734·2	2437·7	2361·5	1187·7	2219·5	3819·5	3748·4	2832·3	4443·8	3326·8	2375·4	2129·3	2776·7	3584·7	2000·1	2235·8	3375·9	2860·2	2643·2	2068·0	3792·3	3245·3	2410·3	1837·6	2942·3	5671·6	4147·4	5310·1
LEGUMINOUS																																							
Number of Species	4	4	4	4	4	4	4	4	4	4	3	2	3	4	4	4	4	4	5	5	3	3	2	2	4	4	3	2	4	3	4	4	4	4	4	4	4	4	2	2	1
1. Trifolium repens	16·2	7·0	6·2	3·1	18·1	50·3	24·9	0·6	1·7	4·1	0·4	0·3	30·4	3·4	14·7	5·8	19·8	3·2	8·5	10·8	0·5	0·4	...	0·5	0·4	0·3	0·3	...	0·5	0·3	0·3	0·4	136·2	21·0	75·0	0·5	122·1	3·8	6·4	3·6	0·6	0·3	...
2. Trifolium pratense	136·7	70·3	27·6	49·4	71·2	87·5	35·6	44·6	1·7	2·9	0·4	...	17·2	17·2	7·9	34·7	47·2	6·0	2·0	9·2	0·5	...	0·3	...	1·5	0·3	...	...	1·2	0·3	1·1	3·4	302·6	211·9	47·9	79·1	348·6	43·2	6·9	13·0	...	...	...
3. Trifolium minus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4. Trifolium procumbens	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5. Lotus corniculatus	55·9	78·3	97·7	93·4	56·2	129·8	116·2	66·9	0·6	0·6	...	...	...	5·7	4·8	6·1	13·3	43·6	65·7	28·6	...	...	...	...	1·9	10·3	10·3	4·1	0·5	2·6	1·7	1·3	56·2	30·8	9·0	2·0	0·8	31·7	50·2	42·6	...	...	...
6. Lotus major	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7. Lathyrus pratensis	39·4	22·7	16·1	56·0	66·8	61·3	55·4	46·6	0·6	50·0	11·2	23·6	49·6	66·9	112·2	189·6	10·4	47·4	74·3	104·5	2·5	1·3	0·7	1·4	0·6	0·3	1·0	1·5	10·2	...	41·5	277·0	89·7	302·0	1853·6	617·6	350·3	260·8	101·3	89·9	7·7	9·1	1·8
8. Ononis arvensis	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2·1	19·3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9. Vicia Cracca	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	247·2	179·3	147·6	201·9	212·3	328·9	229·0	161·9	10·6	57·6	12·0	24·1	97·2	93·2	139·6	236·2	90·7	100·2	152·6	170·9	4·3	1·7	1·0	1·9	4·6	11·2	11·6	5·6	12·5	3·2	44·6	282·1	1092·7	565·7	1984·7	699·2	874·0	339·5	204·7	145·3	9·3	9·6	1·8
MISCELLANEOUS																																									
Number of Species	23	24	23	21	24	30	29	31	9	15	15	17	13	20	25	30	26	27	28	24	18	13	11	11	17	17	13	14	15	15	16	20	22	23	20	23	17	21	21	23	13	13	16
Ranunculaceæ { 1. Ranunculus acris	0·3	0·3	1·2	...	...	10·7	0·9	2·0	...	19·3	4·9	61·5	...	1·1	28·9	53·3	...	3·5	2·1	8·0	0·5	0·4	...	...	0·4	0·7	0·8	2·0	...	...	9·6	14·4	3·5	5·3	8·1	18·2	...	23·3	12·0	39·5	...	...	...
2 and 3. Ranunculus repens et bulbosus	146·2	67·0	46·3	81·6	66·7	52·4	77·5	139·7	85·0	21·6	20·4	60·6	146·2	84·6	43·2	129·3	190·9	45·7	73·7	180·6	101·5	1·6	0·3	...	12·3	2·6	2·0	2·6	34·3	5·1	3·4	9·7	58·0	16·9	8·9	16·3	52·5	11·9	23·7	23·5	9·6	2·7	...
4. Ranunculus auricomus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Caryophyllea .	0·3	0·7	0·3	0·5	2·4	12·6	29·3	20·4	...	...	0·4	...	2·0	0·6	2·3	1·3	1·0	0·6	1·2	4·6	0·5	0·9	...	...	...	...	...	...	...	...	...	...	0·9	0·3	0·4	...	0·4	0·4	0·5	0·9	3·5	1·0	0·7	...	1·6	...
5. Stellaria Holostea	...	...	...	...	...	...	...	0·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7·7	2·0	...	...	...	...	0·3	0·4	...	0·4	0·4	0·5	...	...	...	...	...	...
6. Cerastium triviale	14·1	12·2	14·0	19·4	13·4	30·8	77·5	17·5	...	0·5	2·4	22·2	0·5	2·9	34·5	14·4	14·0	34·3	15·1	22·9	0·5	0·4	0·3	...	...	...	...	...	2·1	1·3	0·5	0·4	2·2	0·9	0·4	0·5	3·6	4·2	2·5	0·2	...	...	...
7. Spergula arvensis	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hypericineæ . { 8. Hypericum perforatum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9. Potentilla reptans	...	...	0·2	0·2	0·3	0·3	0·2	0·4	1·1	...	...	...	...	...	0·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10. Potentilla Fragariastrum	...	...	...	...	...	0·3	0·2	0·2	...	...	0·5	...	...	...	0·3	0·4	0·3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·3	0·3	0·4	...	...	...	3·2	...	0·6
Rosaceæ . . . { 11. Agrimonia Eupatoria	0·3	...	0·3	0·2	...	0·3	0·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12. Poterium Sanguisorba	...	7·0	9·0	20·8	...	...	...	...	...	...	...	...	...	...	3·3	0·7	0·4	0·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0·9	...	...	...	...	0·4	0·3	0·4	...
13. Spiræa Ulmaria	...	...	...	...	...	...	...	...	...	...	...	0·9	...	...	2·5	...	0·3	29·6	1·8	0·5	...	...	...	...	...	...	...	...	...	...	...	...	11·1	2·6	8·7	17·0	...	...	...	0·7	...	0·6
14. Conopodium denudatum	29·6	26·3	46·6	44·9	54·1	168·2	48·9	61·5	61·1	82·5	19·4	26·5	143·2	162·9	32·6	34·7	31·5	62·1	20·7	19·8	61·3	115·3	12·5	5·2	44·3	189·7	22·6	19·2	24·5	251·2	69·7	57·2	69·3	411·0	55·5	80·6	71·9	281·3	44·4	32·9	196·9	503·2	88·6
Umbelliferæ . { 15. Pimpinella Saxifraga	46·7	114·6	14·1	19·8	23·9	30·6	9·5	10·6	3·9	1·8	1·1	0·9	18·2	27·4	4·8	9·8	28·3	113·6	22·7	45·8	29·5	17·0	11·5	0·5	3·9	25·5	3·8	0·3	2·7	19·5	7·7	5·5	30·0	32·5	9·5	14·3	30·6	13·1	27·0	24·3	0·6	0·5	0·6
16. Heracleum Sphondylium	...	...	0·3	...	...	...	...	...	...	...	...	...	...	...	0·4	...	...	...	...	...	1·4	...	...	11·9	...	...	...	...	...	...	2·4	0·3	...	2·4	...	3·2	10·1	...	...	...	3·4
17. Anthriscus sylvestris	...	...	...	...	...	...	...	...	15·2	...	...	...	...	...	1·1	0·6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rubiaceæ . . . { 18. Galium verum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·1	1·7	1·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19. Galium Aparine	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4·3	21·8	21·1	21·9	...	20·2	60·3	6·5	45·2	10·6	22·4	6·8	...	...	...	...	1·4	15·3	9·2	1·1	...	...	...
Dipsaceæ . . . { 20. Scabiosa arvensis	0·3	...	0·3	2·8	1·7	0·3	2·0	1·3	...	...	...	...	...	...	0·3	2·6	...	...	0·2	...	...	...	0·3	2·3	1·2	9·3	15·6	49·3	6·5	21·4	1·1	0·8	0·9	...	...	3·1	27·1	0·4	0·8	17·0	...	17·6	1·7
21. Centaurea nigra	9·5	19·7	34·6	22·1	41·1	29·7	75·5	52·5	...	10·6	43·9	11·8	2·0	8·0	36·2	32·5	14·0	12·7	17·9	20·4	0·5	9·1	39·9	39·9	0·4	80·3	54·8	15·6	...	44·7	39·8	18·6	1·3	35·2	11·4	9·1	10·0	17·2	6·2	27·5	2·6	...	1·1
22. Cardamine arvensis	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·3	49·2	11·8	9·1	...	...	...	...	...
23. Reilia perennis	0·3	1·3	0·2	0·5	...	...	0·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
24. Achillea Millefolium	46·7	39·7	29·3	47·9	59·7	46·6	84·9	60·9	75·0	150·4	177·0	84·1	122·0	62·3	52·9	78·4	48·2	68·5	90·3	98·7	84·1	84·9	55·9	12·7	51·2	36·0	20·4	4·7	148·7	34·5	115·4	72·8	74·9	138·2	221·3	32·6	42·1	187·0	250·4	100·0	124·9	109·3	84·9
25. Chrysanthemum Leucanthemum	...	...	...	2·8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Compositæ . . . { 26. Tragopogon pratensis	0·3	...	0·2	0·2	10·3	11·0	7·4	0·2	...	...	...	...	...	...	0·6	0·7	...	0·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4·0	1·1	...
27. Leontodon hispidus	1·6	21·3	20·9	31·2	9·3	3·0	2·9	1·5	...	...	...	...	...	1·1	0·6	1·4	19·2	21·9	2·0	29·4	...	...	...	...	...	...	...	...	...	...	...	...	0·5	...	...	...	...	...	...	...	...
28. Leontodon autumnalis	...	...	...	...	...	0·2	...	...	...	...	...	...	...	...	...	...	...	0·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29. Taraxacum officinale	1·5	0·4	2·5	1·4	4·1	4·0	0·2	3·0	1·1	10·0	4·6	1·4	...	...	0·6	2·0	1·1	0·4	1·2	1·4	0·4	0·4	...	...	0·4	0·3	0·5	...	0·9	...	...	...	7·1	4·5	...	...	1·4	2·9	1·3	0·4	...	0·5	...
30. Hieracium Pilosella	0·3	0·3	0·2	1·0	...	0·3	0·5	1·7	...	...	...	...	...	...	0·3	0·4	...	0·4	0·2	0·3	...	...	...	...	...	...	...	...	...	...	...	...	0·4	...	...	...	...	...	...	...	...
Plantaginea . . { 31. Plantago lanceolata	224·0	367·5	437·7	774·7	260·0	251·5	9·3	31·0	16·7	30·0	4·9	12·8	84·8	176·1	41·0	132·6	183·1	342·0	55·4	119·9	1·9	...	...	0·3	2·2	0·7	...	...	2·7	...	0·4	10·7	49·0	3·0	4·6	32·1	58·5	9·7	7·4	0·6	0·3	...
Scrophulariaceæ { 32. Veronica Chamædrys	14·7	10·7	2·3	5·7	13·4	14·0	5·2	12·4	...	18·5	1·1	0·5	14·2	24·9	15·4	26·0	9·4	20·9	4·1	24·2	0·4	0·3	...	...	0·4	0·3	...	...	2·1	1·3	0·3	0·4	21·7	19·7	25·0	19·4	2·7	32·9	9·2	5·1	0·6	0·5	...
33. Veronica serpyllifolia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Labiatæ . . . { 34. Prunella vulgaris	0·3	1·0	0·2	2·1	1·0	2·7	0·2	0·7	...	...	...	...	...	...	0·7	1·0	1·4	0·2	0·6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·8	...	...
35. Thymus Serpyllum	...	...	...	2·1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

…ed, illustrating the Domination of one Plant over another in the Mixed Herbage of Permanent Meadow Land.

…roup (Gramineæ, Leguminosæ, and Miscellaneæ), in the total Mixed Herbage of each Plot, in each year of complete botanical separation, 1862, 1867, 1872, and 1877.

"Mixed Mineral Manure"—Sulphates of Potass, Soda, and Magnesia, and Superphosphate of Lime.

| With Potass, 6 years, 1856-61; without Potass, 1862 and since. | | | | With Ammonia-salts = 86 lbs. Nitrogen. | | | | Mineral Manures as Plot 8, and Ammonia-salts = 86 lbs. Nitrogen. | | | | With Ammonia-salts = 172 lbs. Nitrogen; only 86 lbs. in 1859-60-61. | | | | As Plot 11—1 and Silicates in addition, 1862, and since. | | | | With Ammonia-salts = 86 lbs. Nitrogen and Cut Wheat Straw. | | | | With Nitrate of Soda = 86 lbs. Nitrogen. | | | | With Nitrate of Soda = 43 lbs. Nitrogen. | | | | Nitrate of Soda alone. = 86 lbs. Nitrogen. | | | | Nitrate of Soda alone. = 43 lbs. Nitrogen. | | | | Mineral Constituents and Nitrogen of 1 ton Hay. | | | Superphosphate, Nitrate Soda, and Sulphate Potass. | | Superphosphate, and Nitrate Potass. | | Description of Manure. |
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